Essential Science 4

Essential
Science

BOOK 4

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Essential Science

BOOK 4

by Charles Windridge
illustrated by Trevor Stubley

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Author's note

STATE INSTITUTE OF EDUCATION
Govt. of West Bengal

We are living in an age of scientific discovery and achievement. To a large extent, our way of life is governed by machines and technical processes. Therefore, it is very desirable that, when youngsters leave school, they should possess that kind of scientific knowledge which will enable them to understand and appreciate the work of the scientist and its many everyday applications.

The books in this series provide a course in general science for children in secondary schools. Every effort has been made to ensure that the contents are interesting and attractive and truly relevant to the needs of the pupil. The illustrations are bold and colourful. The language used is simple and direct.

The practical work is straightforward and homely and can be performed with the simplest apparatus. This means that the books could be particularly useful in those schools where laboratory facilities are not available.

The written-work is at a minimum and consists of word lists, completing sentences, labelling drawings, brief descriptions, etc. It is felt that the traditional technique for writing-up experiments – apparatus, method, results and conclusions –, while suitable for pupils who are pursuing academic courses, is not suitable for the pupils for whom these books are intended.

Thanks are due to Mrs L. Allen for her help.

C. WINDRIDGE

Important notice

This book, as with the other books in the series, has been fully "metricated and decimalized" in accordance with the Standard International System of Units (Le Système International d'Unitès), known, more simply, as SI, which has been adopted as the national measuring system in the United Kingdom.

Due consideration has been given to the recommendations of the British standards authorities – the British Standards Institution, the Royal Society, the Association for Science Education, the Royal Institute of Chemistry, etc.

Some of the many SI fundamental, derived and supplementary units are:

physical quantity	*unit*	*symbol*
length	metre	m
mass	kilogramme	kg
time	second	s
temperature (customary)	degree Celsius	°C
electric current	ampere	A
area	square metre	m^2
volume	cubic metre	m^3

Further information about SI units can be obtained from these publications:

Changing to the Metric System. Her Majesty's Stationery Office.
Metrication in Secondary Education. The Royal Society.
The International System (SI) Units. The British Standards Institution,
Sales Branch, 101 Pentonville Road, London, N.1.
Physio-Chemical Quantities and Units. The Royal Institute of Chemistry.
SI Units, Signs, Symbols and Abbreviations. The Association for Science Education.

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1 Power

Work and power

There is always some work to be done. Most of our work is done for us by *power* from electric motors and steam and petrol engines. Railway *locomotives* are powered by steam or electricity. Road vehicles are powered by petrol or oil. Factory machinery, vacuum cleaners, hair dryers, etc. are powered by electricity.

Thousands of years ago, long before the invention of electric motors and steam and petrol engines, men did all their work with the power of their muscles. They travelled on foot and carried heavy loads on their backs.

Later on, men learned how to tame animals, such as horses, oxen, donkeys, camels, elephants and dogs, and make them do all sorts of useful jobs. These animals were used to carry men about, lift heavy loads and pull carts and carriages. Horse-drawn vehicles can still be seen on our roads.

Wind and water power

Men have also learned how to harness the power of wind and water.

Windmills are used for grinding corn into flour and for pumping water. Why are there so many windmills in Holland?

Sailing-ships are made to move by the power of the wind. Moving air pushes against their sails.

Water-mills are used for grinding corn and driving machinery.

In countries like Switzerland, where there are many fast-moving rivers, the rivers are dammed. The pressure of the water pushes against the blades of *turbines*. The turbines spin and drive *generators* which make electricity. Electricity made in this way is called *hydro-electricity*. "Hydro" means "water".

Making a "windmill"

Make a "windmill".

Use a pencil and a ruler to draw lines to join the opposite corners of a 15 cm square of paper. Cut down the lines nearly to the centre of the square. Fold the corners over the centre and gum them where they overlap. Use a pin to fix the wheel on the end of a stick. Make sure that the wheel can spin freely.

Blow on the blades. Why does the wheel spin? Now, run with the "windmill" held in front of you. The wheel spins quickly. Why?

A cork sailing-ship

Make a sailing-ship from a cork in the way shown opposite. Use a straw to blow the ship along.

A water turbine

Make a water turbine in the way shown opposite.

A bobbin tractor

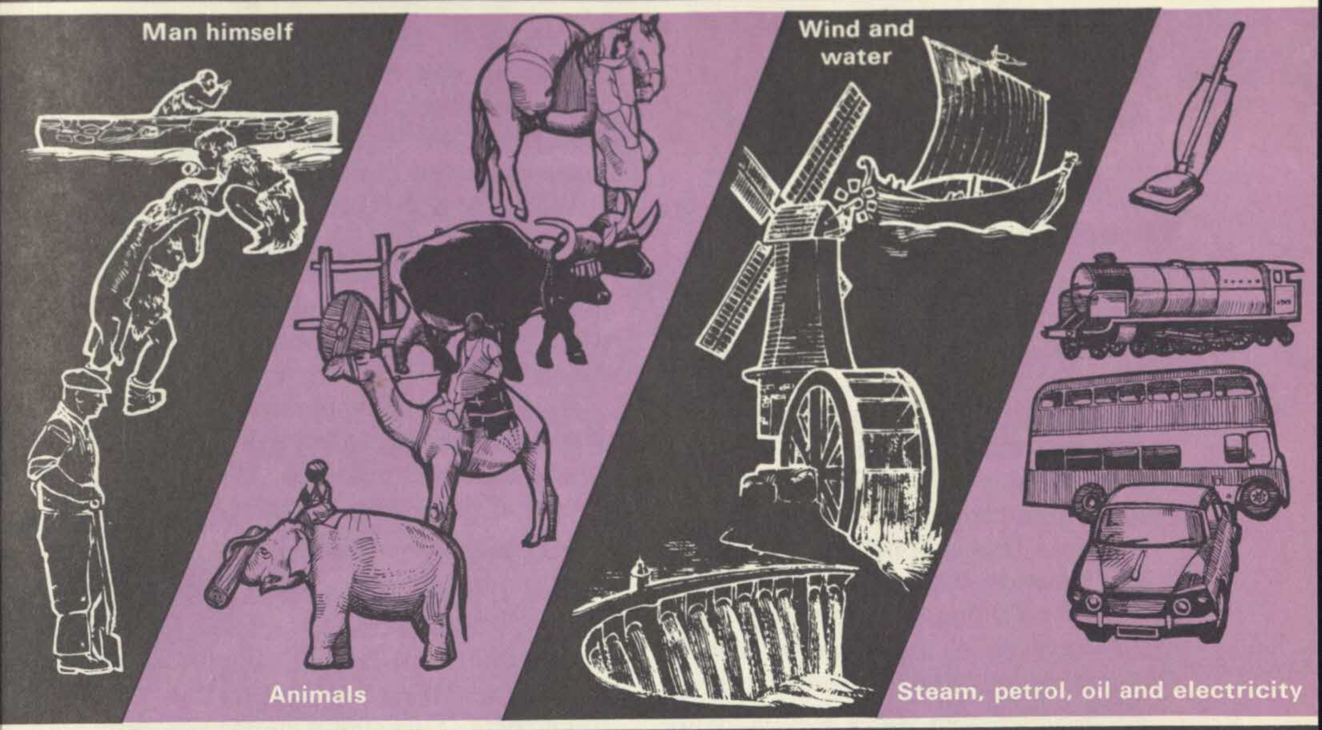
Make a *bobbin tractor* in the way shown opposite.

Cut notches in the edges of the bobbin so that it will grip on a surface. Wind up the rubber band and then place the tractor on a table. The tractor moves along as the rubber band unwinds. The wound-up rubber band stores the power from your finger muscles.

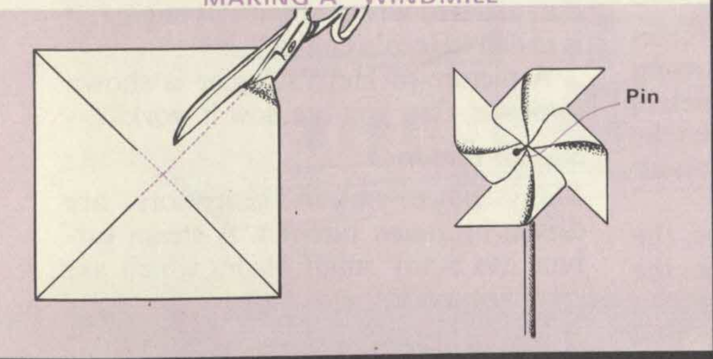
MORE THINGS TO DO

1. Draw a windmill and a water-mill.
2. Make a list of animals that work for men.

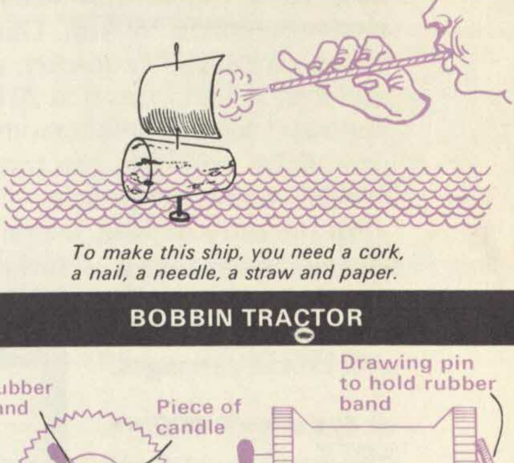
Power



MAKING A "WINDMILL"



CORK SAILING-SHIP

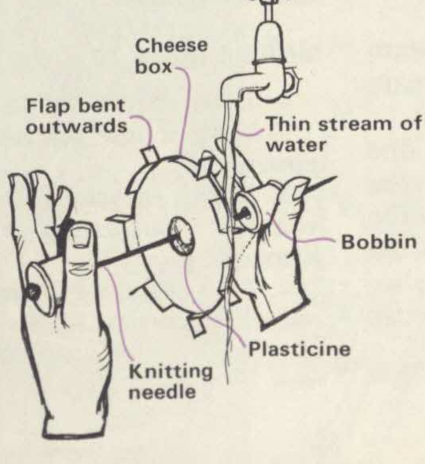


To make this ship, you need a cork, a nail, a needle, a straw and paper.

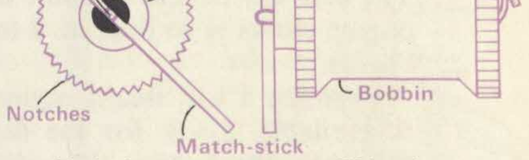
WATER TURBINE

Use scissors to cut flaps in the side of the cheese box.

Smear the box with vaseline so that it is waterproof.



BOBBIN TRACTOR



End view **Side view**

2 The iron horse

Steam power

The most famous name in the history of the steam engine is that of James Watt, a Scottish engineer, who lived about 200 years ago. He did not invent the steam engine, but he made a steam engine that was far better than any that had been made before. His engines were used for pumping water from mines.

It is said that when James Watt was a boy, he once watched the steam push the lid off a boiling kettle and wondered if the power of steam could be used to drive an engine. But this is only a story.

Another famous name among steam engineers is George Stephenson. A number of the earliest steam locomotives were made by him. One of these, which he called *The Rocket*, was strong and fast. It could travel at 20 kilometres per hour! A modern locomotive, like the one shown opposite, can travel at over 160 kilometres per hour.

In the early days of the railways, the steam locomotive was nicknamed the *iron horse* because it was made of iron and was used, instead of horses, to pull trucks and carriages.

A toy steam engine

The best way to find out how the steam engine works is to operate a toy steam engine.

Examine a toy steam engine, if one is available. Look for the *boiler*, the *filler cap*, the *burner*, the *cylinder*, the *piston rod*, the *cylinder valve*, the *steam pipe*, the *fly-wheel* and the *safety valve*.

Operate the engine. Remove the filler cap and pour water into the boiler until it is about one third full. Do this with a small funnel. Fill the burner with methylated spirit. Light it and place it underneath the boiler.

When the water boils, hot, expanding steam passes through the steam pipe into the cylinder where it pushes the piston. The piston rod turns the fly-wheel. The cylinder rocks and waste steam escapes from the cylinder valve.

If the boiler overheats, the steam pressure opens the safety valve and some of the steam is released. What might happen if there were no safety valve?

Hero's engine

About 150 years before the Birth of Christ, a man named Hero, who lived at Alexandria in Ancient Egypt, wrote about a steam engine that he had seen somewhere. This steam engine was only a toy. No one knows who invented it; but, as Hero wrote about this engine, it is called "Hero's engine".

A picture of Hero's engine is shown opposite. Can you see how it works?

Steam turbines

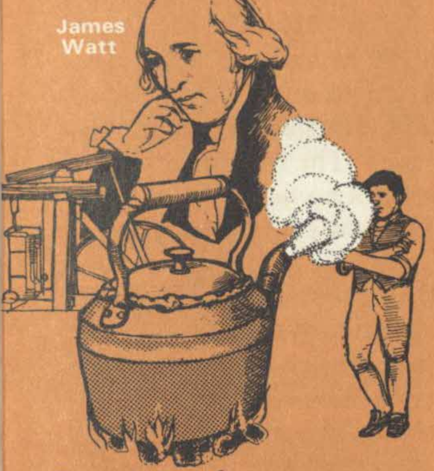
Many power-station generators are driven by *steam turbines*. A steam turbine has many small blades which are spun around by jets of steam.

A model steam turbine

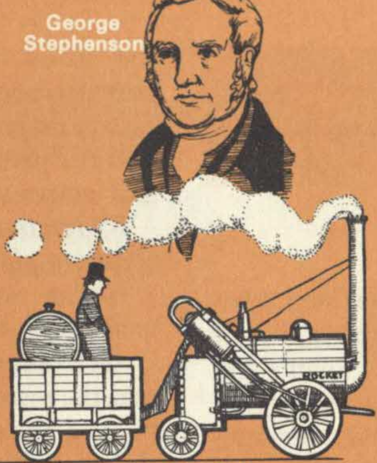
Make a model steam turbine in the way shown opposite.

MORE THINGS TO DO

1. Draw Hero's engine.
2. Write a few sentences about steam power.
3. Use an encyclopedia to find out what you can about James Watt and George Stephenson.
4. Look for the cylinder and the piston rod when you next see a steam locomotive.



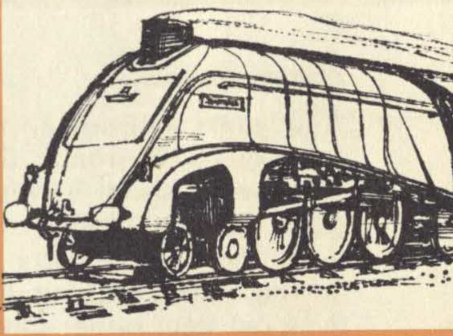
The power of steam

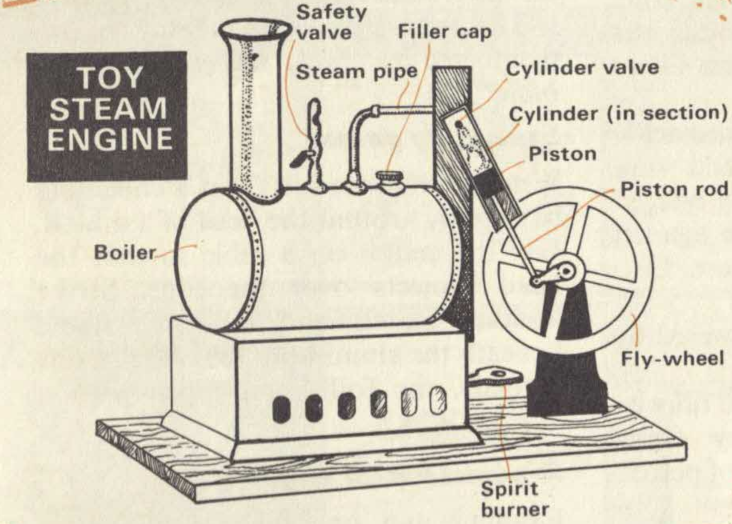


The Rocket

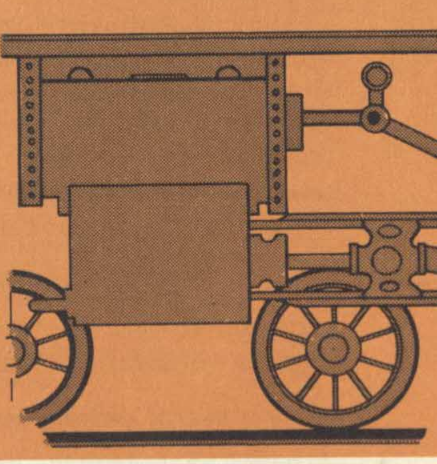
The iron horse

Modern steam locomotive

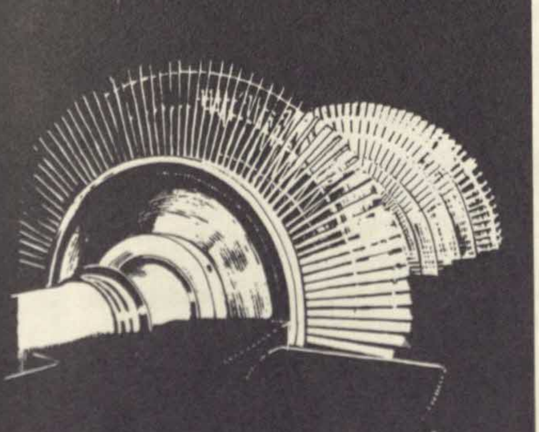




Cylinder and piston rod on a real locomotive

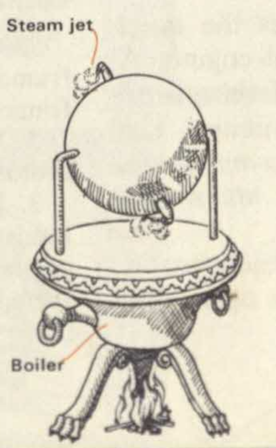


STEAM TURBINE

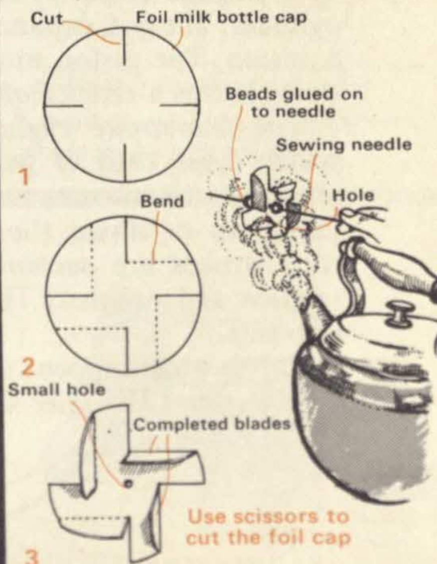


The cover has been removed to show the blades

HERO'S ENGINE



MODEL STEAM TURBINE



3 The horseless carriage

The motor-car

A long time ago, some writer said that, one day, on our roads, there would be "carriages without horses". People living at the time scoffed at what he had said. The idea of carts and carriages moving along without horses to pull them did seem rather silly.

But, the writer's words came true. About 100 years ago, the motor-car was invented. It was soon called the *horseless carriage*.

The first motor-cars were ramshackle affairs. They had solid tyres and were slow and unreliable. Also, they offered their passengers no protection against bad weather. Modern cars are fast, reliable and comfortable.

Of course, a motor-car is powered by a petrol engine.

Omnibuses, heavy lorries and railway locomotives are powered by diesel engines which burn oil instead of petrol.

How a petrol engine works

A petrol engine works by the explosion of a mixture of petrol and air inside a cylinder. The hot, expanding gases push a piston. The piston moves and, in so doing, turns a *crankshaft*.

The *four-stroke engine* is the most widely used kind of petrol engine. A stroke is the movement of the piston either up or down the cylinder. The four strokes are *suction*, *compression*, *ignition* and *exhaust*. They are shown opposite.

This is what happens on each stroke.

1. *Suction*. The *inlet valve* opens and the piston falls. A mixture of air and petrol vapour is sucked into the cylinder.

2. *Compression*. The inlet valve closes and the piston rises. The mixture of air and petrol vapour is compressed.

3. *Ignition*. Electric sparks from the *sparking-plug* ignite the petrol vapour. It burns rapidly. The hot, expanding gases push the piston downwards.

4. *Exhaust*. The *exhaust valve* opens and the piston rises. The waste gases are pushed out of the cylinder.

The valves are made to open and close at the right times by *cam-wheels* on the crankshaft.

The four strokes can easily be remembered as "*suck, squeeze, bang* and *blow*".

Expanding gases

Wrap aluminium foil from a chocolate bar tightly around the head of a match. Lay the match on a table so that the head projects over the edge. Strike another match and hold the flame beneath the aluminium foil. After a few seconds, the foil bursts open with a "pop". Why?

A model petrol engine

Examine and operate a small petrol engine of the kind used to power model aeroplanes, if one is available. Follow the maker's instructions. Perhaps your teacher will help you with this.

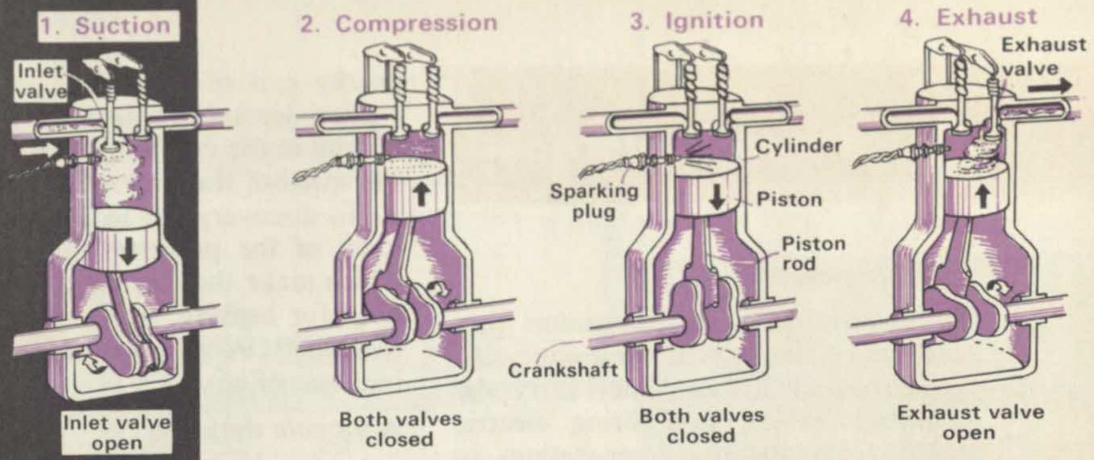
MORE THINGS TO DO

1. Copy the drawings shown in the black frame opposite. Do not draw the black frame.

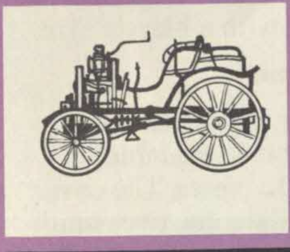
2. Write a few sentences about the motor-car.

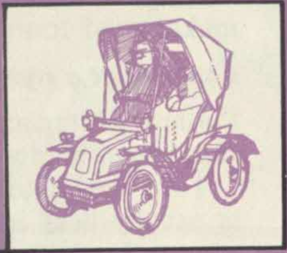
3. Find pictures of road vehicles of all kinds in old magazines, comics, newspapers, etc. Cut out the pictures and paste them into your notebook.

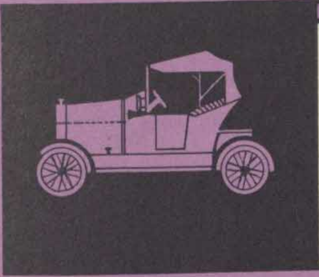
The horseless carriage

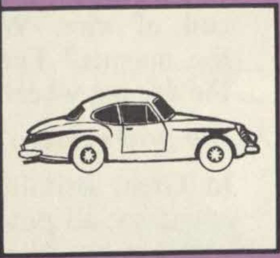


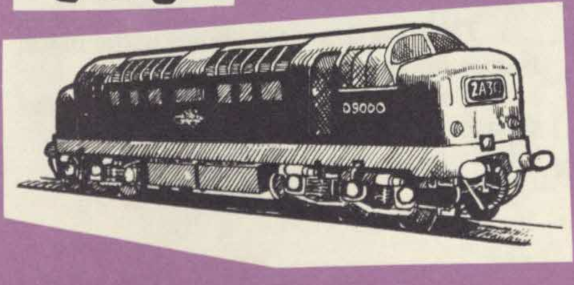
HOW A PETROL ENGINE WORKS



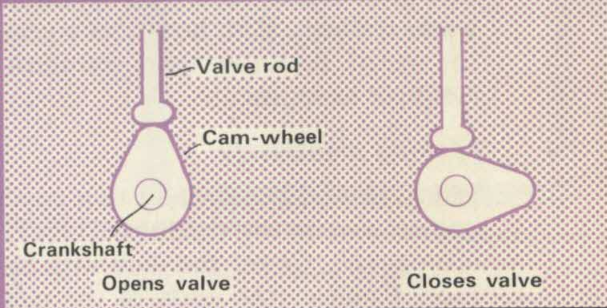


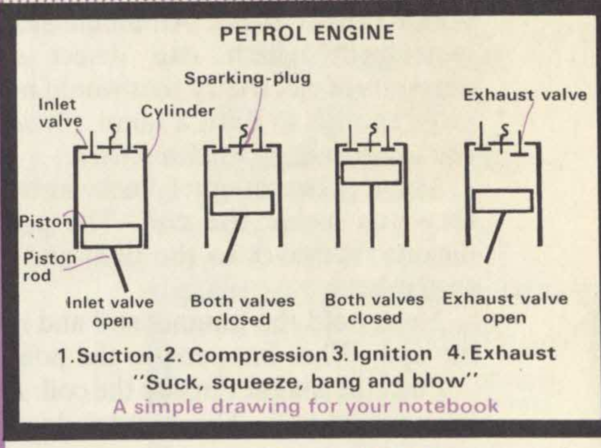






CAM-WHEELS

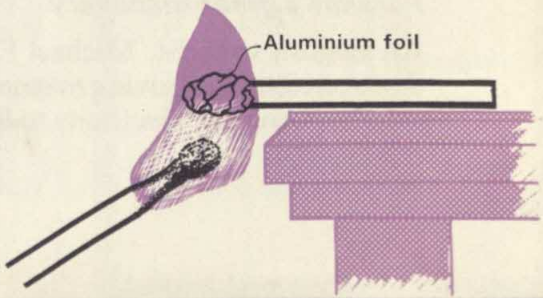




"Suck, squeeze, bang and blow"

A simple drawing for your notebook

EXPANDING GASES



4 Power overhead

Electric power

Those tall towers of iron girders that stretch in a line across the countryside are *electricity pylons*. They carry the overhead cables that bring electric power from distant power-stations to factories, hospitals, schools, houses, etc.

Power-stations make enormous quantities of electricity. The electricity is made by machines called *generators*. The generators are driven by steam or water turbines. But, how does a generator work? To know that, you must do a simple experiment.

Making electricity

Wind about 15 metres of thin covered copper wire on to a cardboard tube from a toilet roll. Cover the wire with Sellotape. Connect the ends of the coil of wire to an *ammeter*. An ammeter is an instrument which can detect small amounts of electricity that would not be large enough to light a lamp. (*Teacher: use a centre-zero milliammeter.*)

Move a bar magnet backwards and forwards inside the coil. The pointer flickers; it moves to the right and then to the left.

Now, hold the magnet still and move the coil. What happens to the pointer?

Push the magnet inside the coil. Hold the magnet still. The pointer does not move.

Faraday's great discovery

An English scientist, Michael Faraday, discovered that a moving magnet would cause a current of electricity to flow in a nearby coil of wire. The size of the current depends on the number of turns of wire in the coil and the strength and the speed of the moving magnet.

His discovery has led to the development of the power-station generators which make the electric power that we need for heating, lighting and driving machinery. A generator contains moving coils of wire.

A bicycle dynamo

A bicycle *dynamo* is a small generator. It is a simple machine. A *driving wheel* spins a strong magnet just above a coil of wire inside a cup-shaped case. The driving wheel has a milled edge which makes good contact with a bicycle tyre.

Looking at a dynamo

Perhaps your teacher has an old dynamo that he will allow you to examine.

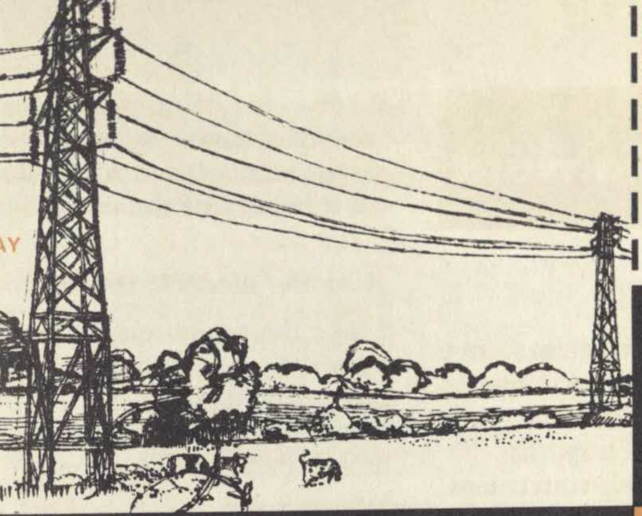
Take the dynamo to pieces. The cover is usually held in place by two small screws. Look for the magnet and the coil of wire. What is the shape of the magnet? Feel the milled edge of the driving wheel.

The grid system

In Great Britain and in many other countries, all power-stations are linked together by overhead cables to make what is called the *grid system*. This system carries electric power to all parts of Britain. The electricity supply is not affected by a breakdown in a local power-station. If one power-station is unable to supply electricity, then, other power-stations will supply it.

MORE THINGS TO DO

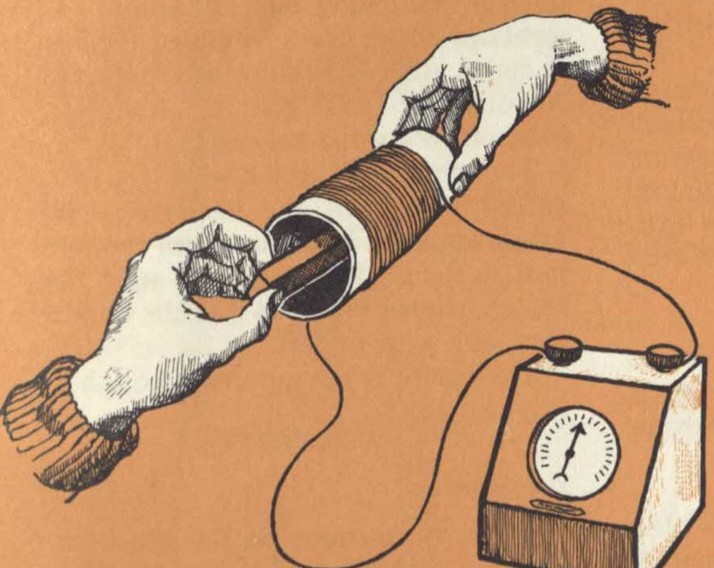
1. Copy the drawings shown in the black frames opposite.
2. Copy the paragraph about the grid system.



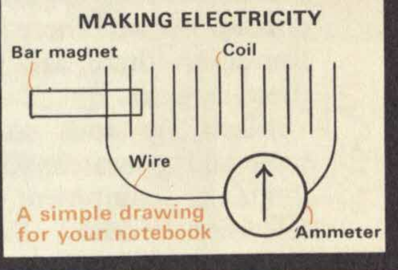
MICHAEL FARADAY

MAKING ELECTRICITY

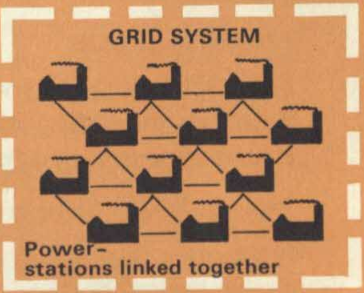
"Our Greatest Experimenter and the Father of Electricity"



Power overhead

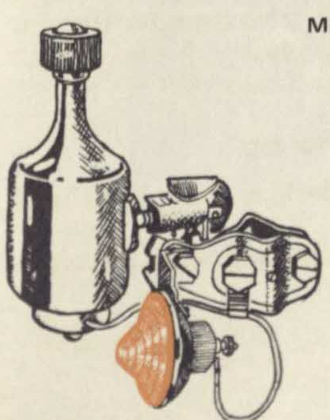


A simple drawing for your notebook

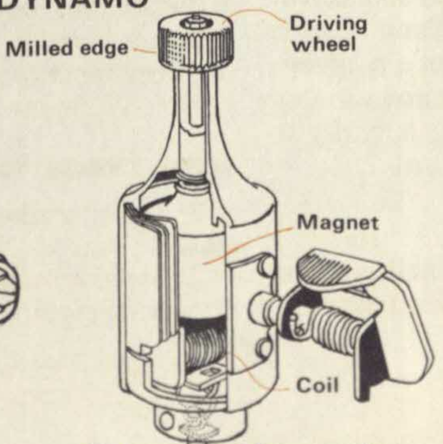


Power-stations linked together

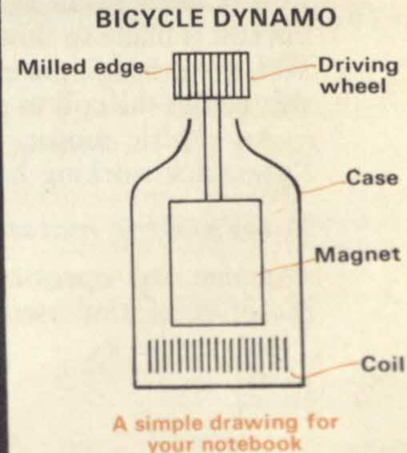
BICYCLE DYNAMO



Dynamo and rear lamp



Cut open to show parts



A simple drawing for your notebook

5 Electricity at work

Electricity is convenient

Electricity is our most convenient source of power. It can be carried by cables to almost any position. It is soon made available by the throw of a switch.

But, electricity is not only convenient, it is also clean and free from smells. There are no soot and ashes, as there are with steam engines, coal fires and coke stoves, and there are no unpleasant fumes, as there are with petrol and diesel engines.

Electricity does so many different jobs and operates so many different kinds of equipment – electro-plating, television, radio, *X-rays*, radiators, cookers, refrigerators, *fluorescent lighting*, etc.

Electric motors

Electric motors do lots of work for us. Some of the things that are driven by electric motors are shown opposite.

How an electric motor works

How does an electric motor work? In a generator, a coil of wire is made to spin around between the ends of a magnet. This causes an electric current to flow in the wire. In a motor, an electric current is made to flow in a coil of wire which is between the ends of a magnet; this causes the coil to spin around.

An electric motor, then, is really a "generator working backwards".

A toy electric motor

Examine and operate a small electric motor of the kind used to drive models, if one is available. Use paper clips and covered copper wires to connect the motor to a battery. Make sure that you use a battery of the correct voltage.

A model electric motor

Make the model electric motor shown opposite and then you will find out more about how an electric motor works. This is not an easy model to make. Perhaps your teacher will help you.

Use paper clips to connect the wires from the drawing pins to a 6 V cycle battery. The cork should spin very quickly. You may have to adjust the positions of the *brush wires* and the bar magnets. Also, the motor will run more smoothly if you put a little thin machine oil on the bearings.

The motor will not start of its own accord unless, at the beginning, the brush wires are in contact with the two pins in the cork. Usually, to start the motor, you will have to give the cork a turn with your fingers.

This motor is not powerful enough to drive models.

A magneto

The electric current to the sparking-plugs of a petrol engine is made by a simple generator that is called a *magneto*. Many coils of wire spin around between the ends of a very strong magnet. Sparks travel across the gap between metal *points*.

MORE THINGS TO DO

1. Draw a sparking-plug. Label each part.
2. Make a list of things that are driven by electric motors.

Electricity at work

Trolley bus

Locomotive

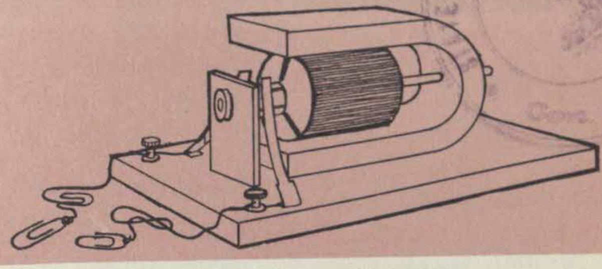
Tram-car

Vacuum cleaner

Hair-dryer

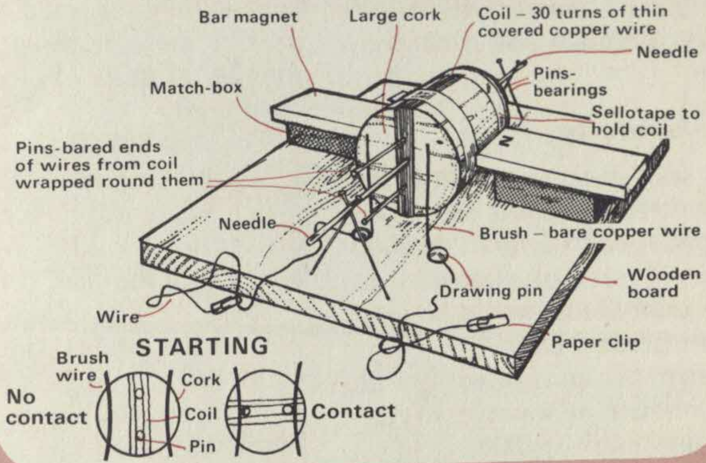
Shaver

TOY ELECTRIC MOTOR



Govt. of West Bengal

MODEL ELECTRIC MOTOR



Sewing machine

Milking machine

Tape recorder

Record player

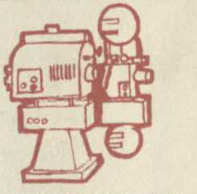
Coffee grinder

Fan

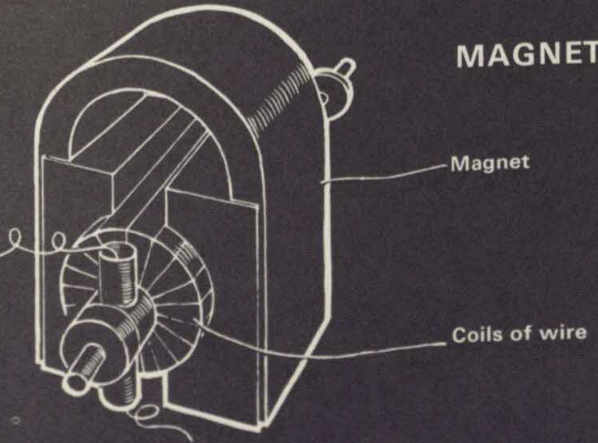
Washing machine

Drill

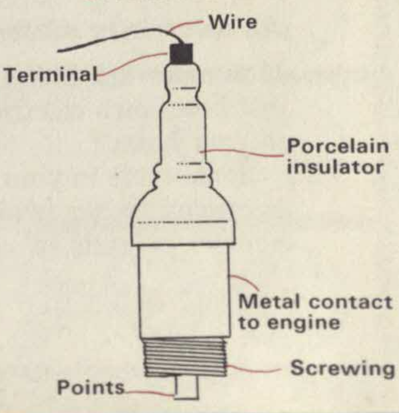
Lawn mower


Cinema projector

MAGNETO



SPARKING-PLUG



6 Paying for electricity

Measuring electric power

Electric power is measured in *watts*. An electrical appliance usually has its *wattage* and working voltage marked on it. A lamp that is marked *240 V 60 W* uses 60 watts of electric power and must be connected to a 240 V supply. Of course, "W" means "watts". A 2000 W fire uses twice as much power as does a 1000 W fire.

Paying for electricity

Electricity is sold in *units*. A unit is the quantity of electricity that is used by a 1000 watt appliance in 1 hour. A 2000 watt fire uses 1 unit of electricity in ½ hour. How many units would be used by a 1000 watt fire in 5 hours?

The number of units used by an electrical appliance = wattage of appliance × hours used ÷ 1000.

The cost of running an electrical appliance for a certain time = price of a unit × number of units used. The price of a unit is given on an electricity bill.

What is the cost of running a 100 W lamp for 40 hours if the price of 1 unit is 2p?

Units used = 100 × 40 ÷ 1000 = 4.
Cost = 2p × 4 = 8p.

An electricity meter

How does the Electricity Board know just how much electricity has been used in your home?

Somewhere in your house, there is an electricity *meter* which measures the number of units of electricity that has been used. This meter is the property of the Electricity Board.

The meter is read every three months by an official of the Electricity Board. When the meter has been read, the Board sends a bill which shows the number of units that has been used and what must be paid for them.

Reading a meter

Look at an electricity meter. The school meter will do for this.

The dials look like clocks, but, of course, they are not clocks because they do not measure time. They show the number of units of electricity that have been used.

The disc below the dials turns when power is being used. Is it turning now? When many appliances are in use, the disc turns quickly. When only a few are in use, the disc turns slowly.

Read the dials from left to right. Do not bother about the top dials; they show tenths and hundredths of a unit. A pointer must be read as showing the figure that it has last passed and not the one to which it may be nearest. Take the previous reading away from this one to find the number of units that have been used since the previous reading.

MORE THINGS TO DO

1. Read the meter dials A, B, C and D shown opposite.

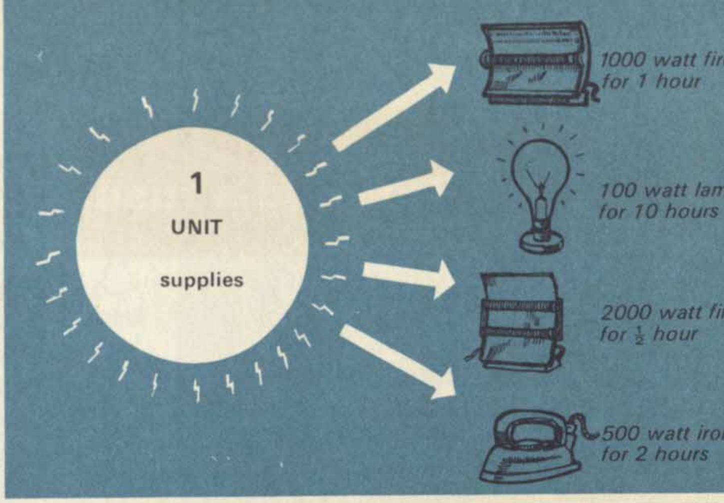
2. Work out the cost of running each of these appliances for the hours given.

Appliance	Wattage	Hours used	Price per unit
Lamp	100	100	1p.
Fire	2000	10	1½p.
Toaster	500	40	2p.
Iron	400	20	1p.

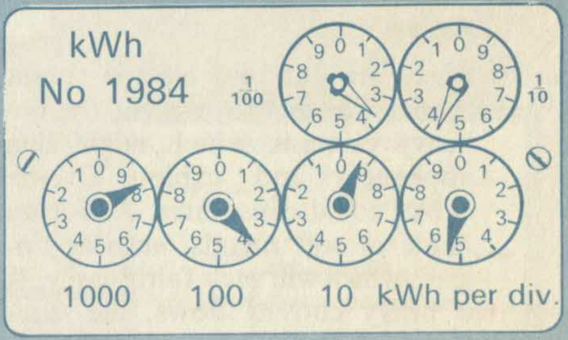
3. With your parents' permission, read the electricity meter in your home.

Paying for electricity

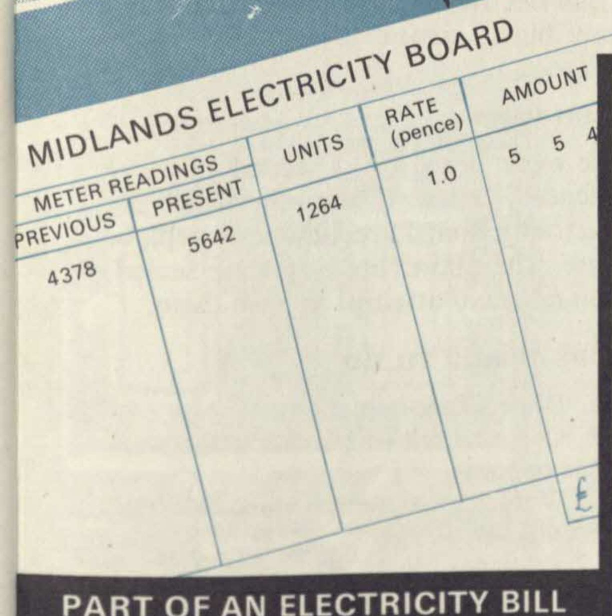
Lamp marked with its wattage and working voltage



ELECTRICITY METER



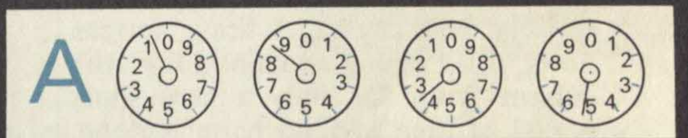
These meter dials show 8395 units

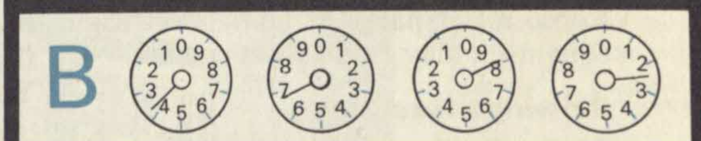


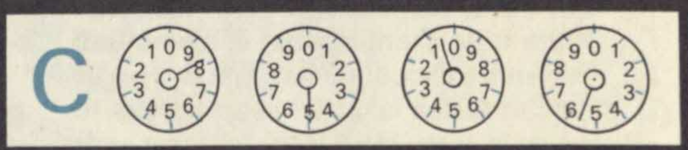
MIDLANDS ELECTRICITY BOARD

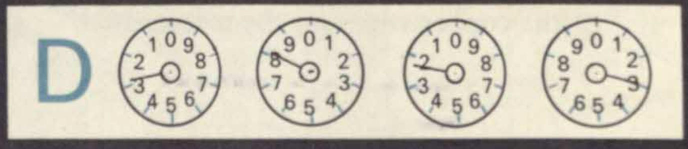
METER READINGS		UNITS	RATE (pence)	AMOUNT
PREVIOUS	PRESENT			
4378	5642	1264	1.0	5 5 4
				£

PART OF AN ELECTRICITY BILL









7 Blowing a fuse

Your electricity supply

Electricity enters your house through a well-insulated cable that leads to the *main fuse-boxes* and the meter. Cables from the meter enter the *switch-box*. The switch-box contains *fuses*. Cables from the switch-box branch out to different points in the house.

Fuses

Fuses are put into electric circuits as "safety valves" to prevent the flow of heavy currents which might damage appliances and cables. Overheated cables could cause fires. *Fuse-wires* are made of soft metals, such as tin and lead, which will melt fairly easily. When a heavy current flows, the fuse-wire becomes hot and melts almost immediately. In this way, the circuit is broken. We call this *blowing a fuse*.

Short circuits

Sometimes, the bare ends of live cables touch each other accidentally and so cause a *short circuit*. A heavy current flows. If the circuit contains a fuse, the current flows for only a very short period of time and no harm is done. Loose metal parts in faulty electrical equipment may cause short circuits.

Blowing a fuse

Cut out a strip, about 8 cm long and 3 mm wide, from a piece of aluminium foil from a chocolate bar. Use two paper clips to fasten covered copper wires to the ends of the strip. Hold the free ends of the copper wires on the terminals of a 12 V car battery. This makes a short circuit. What happens to the foil fuse? *Watch your eyes!*

Replacing a fuse

Open a switch-box and look at the *fuse-holders* inside it. You will find that the box cannot be opened unless the switch is in the "off" position. Do not touch any of the metal parts inside the switch-box. *Electricity is dangerous!*

Do *not* remove these *fuse-holders*. Perhaps, your teacher will show you a spare fuse-holder. Notice that the fuse-wire is connected to *knife contacts* by two small screws. Also, notice that the fuse-holder is made of porcelain or plastic. These materials are good insulators of electricity.

If ever you do have to replace a blown fuse, make sure that you use the correct size of fuse-wire. A card carrying spare fuse-wire in different sizes can be purchased. If the fuse-holder is marked 15 A, then use 15 A fuse-wire; if it is marked 30 A, use 30 A fuse-wire, and so on.

Do not replace a blown fuse-wire with ordinary wire. Why?

An electrician should be called in if a fuse blows again after it has been replaced.

Main fuses

The *main fuses* are a second "line of defence", but only the officials of the Electricity Board are allowed to replace these. The main fuse-boxes are sealed. You must *not* attempt to open them.

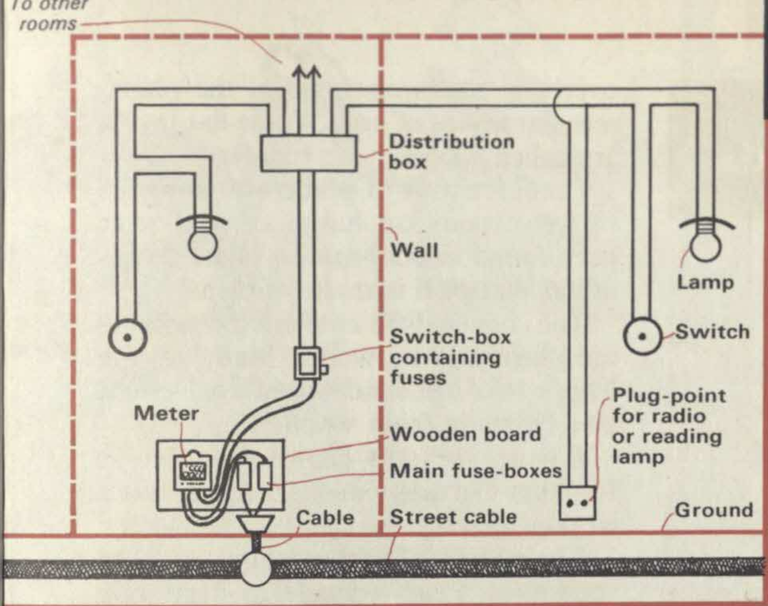
MORE THINGS TO DO

1. Draw a fuse-holder.
2. Copy the drawing shown in the black frame opposite.
3. Write a few sentences about fuses and short circuits.

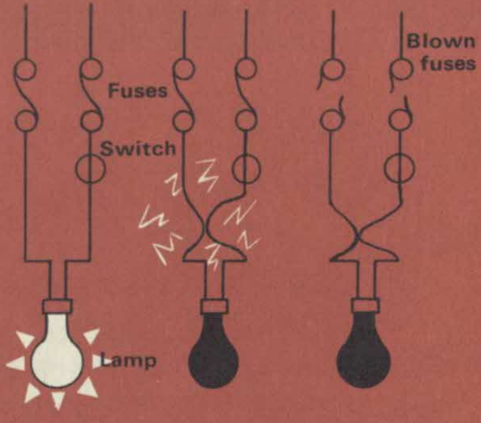
Date 29.8.05
Accn. No. 11864
Library

Blowing a fuse

YOUR ELECTRICITY SUPPLY

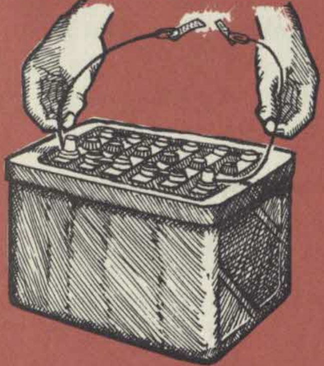


SHORT CIRCUIT

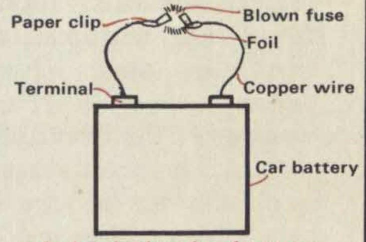


1. Power on 2. Short circuit 3. Power off

BLOWING A FUSE

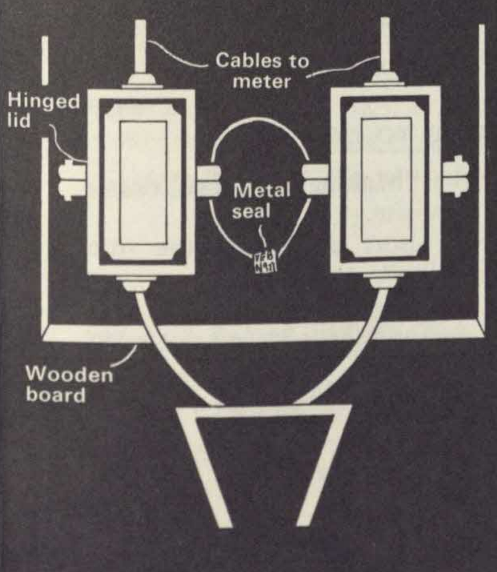


BLOWING A FUSE

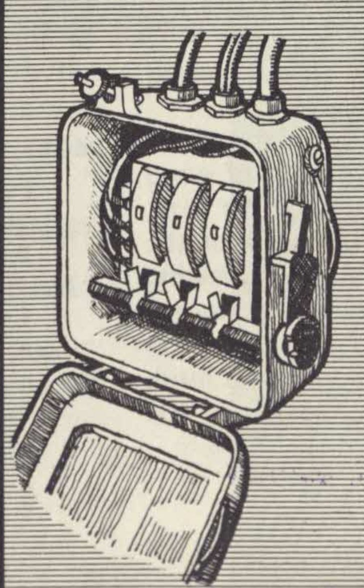


A simple drawing for your notebook

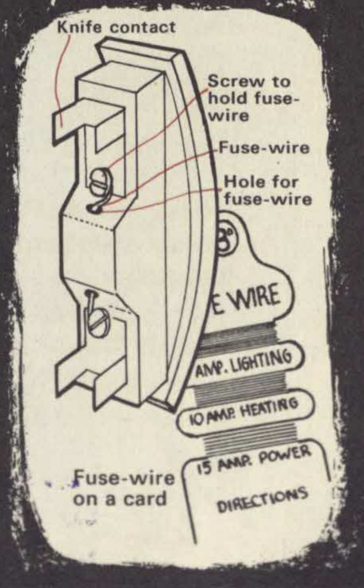
MAIN FUSE-BOXES



SWITCH-BOX



FUSE-HOLDER



8 "Black diamonds"

Coal: a valuable mineral

Much of the heat that we use comes from coal. Coal fires warm our homes and boil the water that we need for washing and cleaning. Coal fires heat the boilers of steam turbines in electricity power-stations.

Coal-gas, coke, tar, oils and many useful chemicals, such as fertilizers, flavourings, perfumes, dyes and medicines, are made from coal. Large quantities of coke are used in the *blast furnaces* of the iron and steel industry.

Coal is a very valuable *mineral* and it is black. That is why it is sometimes called "*black diamonds*".

We ought to be grateful to the coal-miners who work hard underground so that we shall get a good supply of "black diamonds". Would you like to be a coal-miner?

Coal is wood

But, what is coal? It is compressed wood.

Millions of years ago, on parts of the earth, there were vast forests of giant plants which, though larger in size, looked like the ferns and some of the other flowerless plants that are growing today. *Earthquakes* and other movements in the earth's surface caused these woody plants to be covered with mud, sand and rocks. The weight of the overlying rocks compressed the plants into flat layers of coal. These flat layers are called *seams*.

Fossil remains of plants and imprints of fern fronds on lumps of coal have been found in coal-mines. These things tell us that coal is made of plants.

The chemicals in coal are the same as the chemicals in wood. Many of the things that are made from coal could also be made from wood.

Lignite, the soft brown coal that is found in Germany and Australia, has a woody texture.

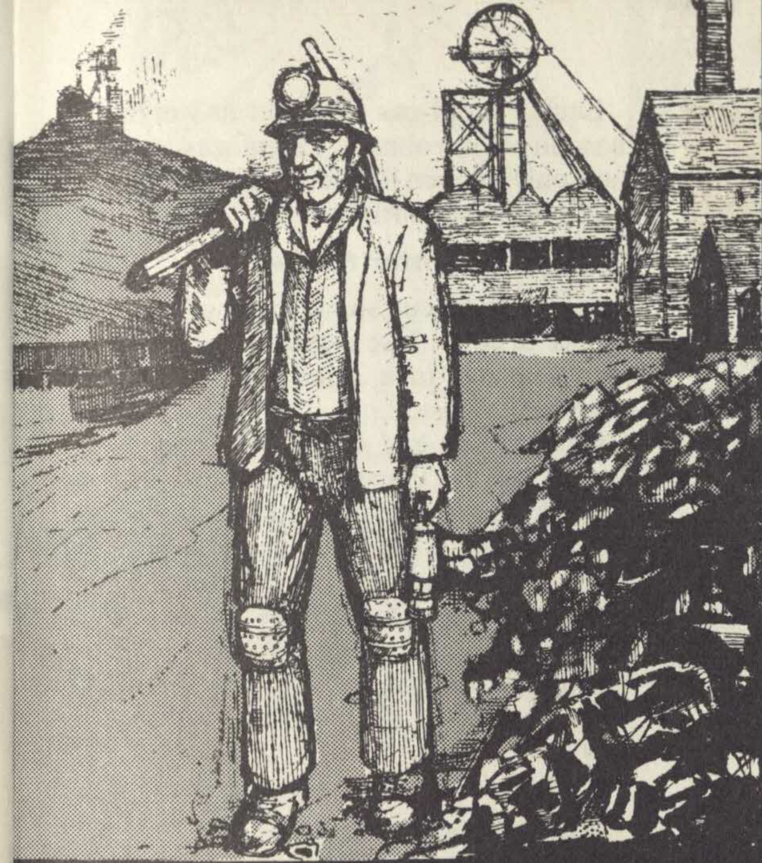
The people of Ireland burn *peat* on their fires. Peat is made of dead bog plants that collect in marshy ground. It is cut into blocks with spades and then stacked in heaps so that it can dry. Peat is brown and soft, but if it were compressed, it would become black and hard like coal.

Making coal-gas

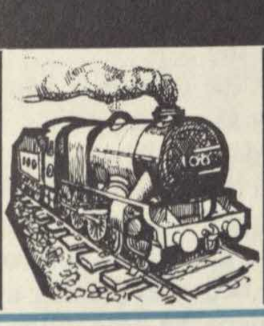
Use a hammer and a nail to make a small hole in the lid of a can. Put a few small lumps of coal in the bottom of the can and place the lid in position. Stand the can in a coal fire. Ignite the gas which comes out of the hole in the lid. When the gas flame goes out, pick up the can with tongs and place it on a brick. When the can is cool, take off the lid. Look at the substance inside the can. It is coke.

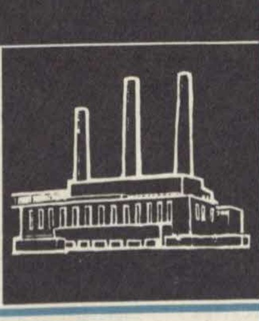
MORE THINGS TO DO

1. Copy the **"Making Coal-Gas"** drawing shown opposite.
2. Write a short essay with the title "*Black Diamonds*".
3. Look up the words "mineral" and "fossil" in a dictionary and find out what they mean.
4. Visit a coal-mine if you get a chance.

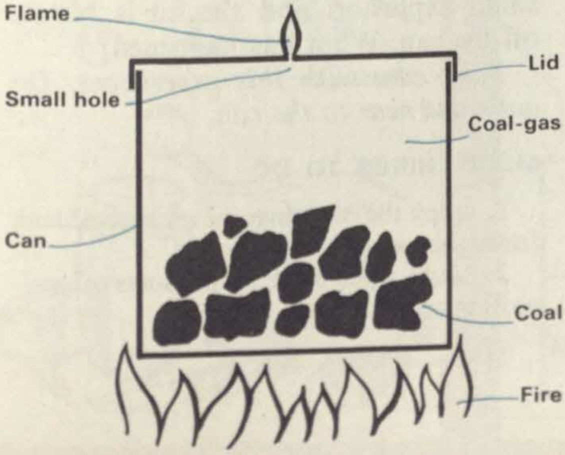


"Black diamonds"





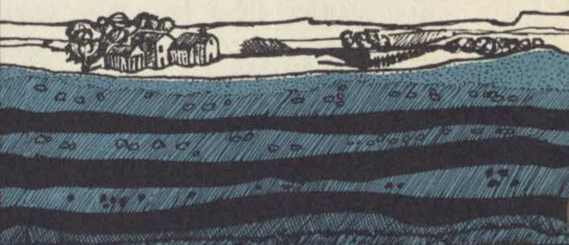
MAKING COAL-GAS



COAL IS WOOD

A forest of long ago

COAL SEAMS



Fossil shell

Fern imprint

Fossil tree trunk

Lignite

Peat

9 Coal-gas

Coal-gas manufacture

In most of the large towns and cities in Great Britain, there are gas-works. They manufacture large quantities of coal-gas. You have made coal-gas by heating some coal inside a can. A gas-works makes coal-gas in the same way. Coal is heated in large ovens that are called *retorts*. The gas from the retorts is cleaned and then stored in large *gas-holders* from which it is pumped through pipes to the houses, factories, hospitals, laboratories, etc. where it is used.

Using coal-gas

Coal-gas has many uses. Some of the many appliances that use coal-gas are shown on the page opposite.

By-products of coal-gas manufacture

When coal-gas is cleaned, all sorts of chemicals, such as *ammonia, sulphur, tar*, etc., are collected. They are used for making fertilizers, dyes, perfumes, medicines, flavourings and many other useful things. These things are called the *by-products of coal-gas manufacture*.

Coal-gas is dangerous

Coal-gas can be dangerous for two reasons.

1. It is poisonous.
2. If it is ignited, a mixture of coal-gas and air will burn very quickly to make an explosion.

You must never leave the gas turned on and unlit. Also, you must never take a flame where there is a gas leak.

Luckily, coal-gas is lighter in weight than air. If a room is full of gas, you have only to open the door and windows and it will soon drift away.

Coal-gas is lighter than air

Use a knife to cut some shavings from a piece of soap. Use a spoon to stir the soap shavings in a small jar of warm water.

Connect one end of a rubber tube to the gas supply. Place the other end just beneath the surface of the soapy water. Turn on the gas. After a bit of practice, you will become expert at making soap bubbles filled with coal-gas. The soap bubbles rise to the ceiling. Why?

Strike a match and bring its flame close to some of the bubbles. Why do they burst into flame?

Take care! Coal-gas is poisonous.

A coal-gas explosion

Use a hammer and a nail to make a small hole in the lid of a can. Make a larger hole, about 1½ cm wide, in the bottom of the can.

Support the can on a bunsen burner in the way shown opposite. Make sure that the lid fits fairly loosely.

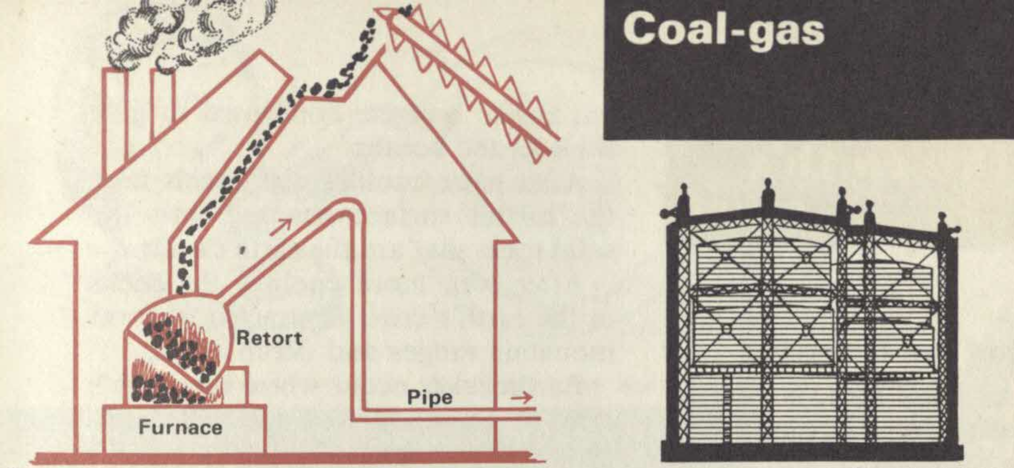
Turn on the gas. After a few seconds, ignite the gas which escapes from the hole in the lid. Then, turn off the gas. The flame becomes smaller and smaller and air enters the hole in the bottom of the can. After a minute or so, there is a small explosion and the lid is blown off the can. What has happened?

Take care with this experiment. Do not stand near to the can.

MORE THINGS TO DO

1. Copy the drawing shown in the black frame opposite.
2. Make a list of 15 by-products of coal-gas manufacture.

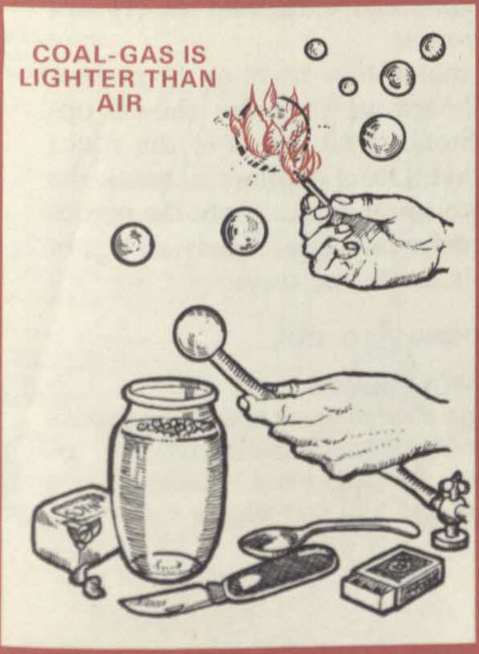
Coal-gas



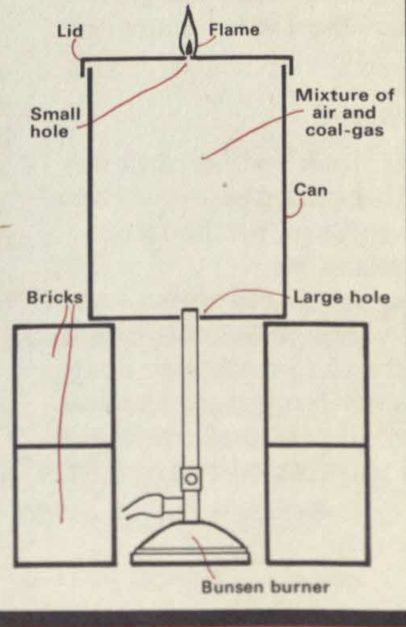
COAL-GAS MANUFACTURE

BY-PRODUCTS OF COAL-GAS MANUFACTURE

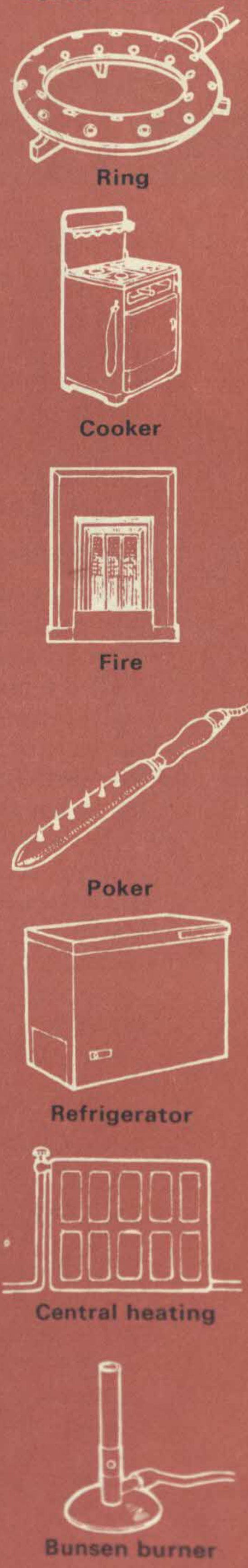
COAL-GAS IS LIGHTER THAN AIR



COAL-GAS EXPLOSION



USING COAL-GAS



10 The earth's crust

A loaf of bread and the earth

The inside of a loaf of bread is soft; the outside is a hard crust. The earth is like a loaf of bread because it, also, is soft on the inside and hard on the outside. The thin layer of hard rocks on the outside of the earth is sometimes called the *earth's crust*.

Inside the earth

We know very little about the inside of the earth. But, we do know that it is very hot and very heavy. It is probable that it is made of a mixture of iron and *nickel*. Iron and nickel are metals and they are much heavier than the rocks in the earth's crust. The inside of the earth is so hot that it is soft or even liquid. *Volcanoes*, which erupt hot gases and molten rocks, called *lava*, show that there are hot, liquid rocks below the earth's surface. Hot springs and *geysers* show that there are hot rocks quite near to the earth's surface. There are geysers in Iceland, Italy, the United States and New Zealand.

What is the earth?

Many scientists think that the earth was once a ball of burning gases which was pulled out of the sun by the force of gravity of a passing star.

When the gases cooled down – and this must have taken millions of years –, they condensed to become liquids. Some oxygen and some nitrogen remained as gases. They are the atmosphere. Water vapour, which was formed by hydrogen burning in oxygen, condensed to give the seas and oceans.

After more cooling, the liquids near the earth's surface changed into the solid rocks that are the earth's crust.

After even more cooling, the rocks in the earth's crust contracted to form mountain ranges and ocean deeps.

Earthquakes occur where the earth's crust is unsteady and has not completely settled down.

The earth's crust

The earth's crust is no more than about 50 km thick. It contains rocks of many different kinds. We make good use of some of these rocks. Building materials are made from such rocks as *marble*, *granite*, *slate* and *sandstone*.

Coal, oil, metals, chalk and other useful minerals are found among the rocks in the earth's crust.

Collecting rocks

Make a collection of common rocks. This is something you can do at home.

A picture-book of rocks will help you to find out their names.

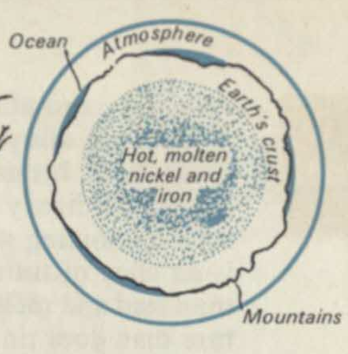
Some of the common rocks that you should collect are: granite, *basalt*, *quartz*, *pumice*, sandstone, clay, *limestone*, *chalk*, coal, slate, marble, *gypsum* and *iron-stone*.

Glue match-box trays on to a sheet of cardboard in the way shown opposite. Store small pieces of the rocks in the trays. Use a hammer to break the rocks into small pieces. Print the names of the rocks on paper labels and gum the labels inside the trays.

MORE THINGS TO DO

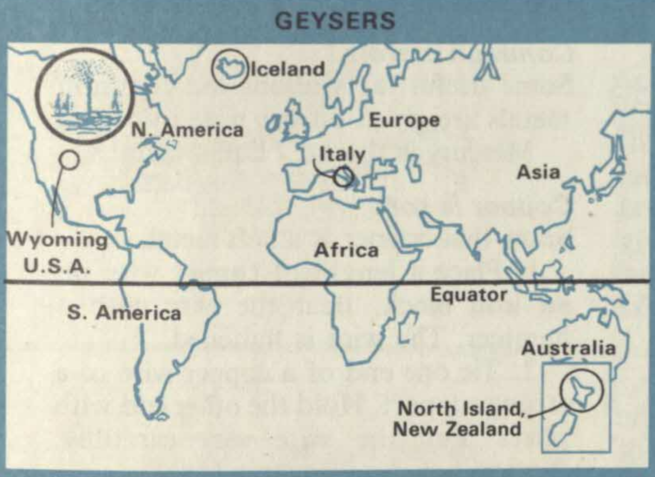
1. Draw a volcano.
2. Make a list of some of the useful rocks and minerals in the earth's crust.
3. Look up the word "geyser" in a dictionary and find out what it means.

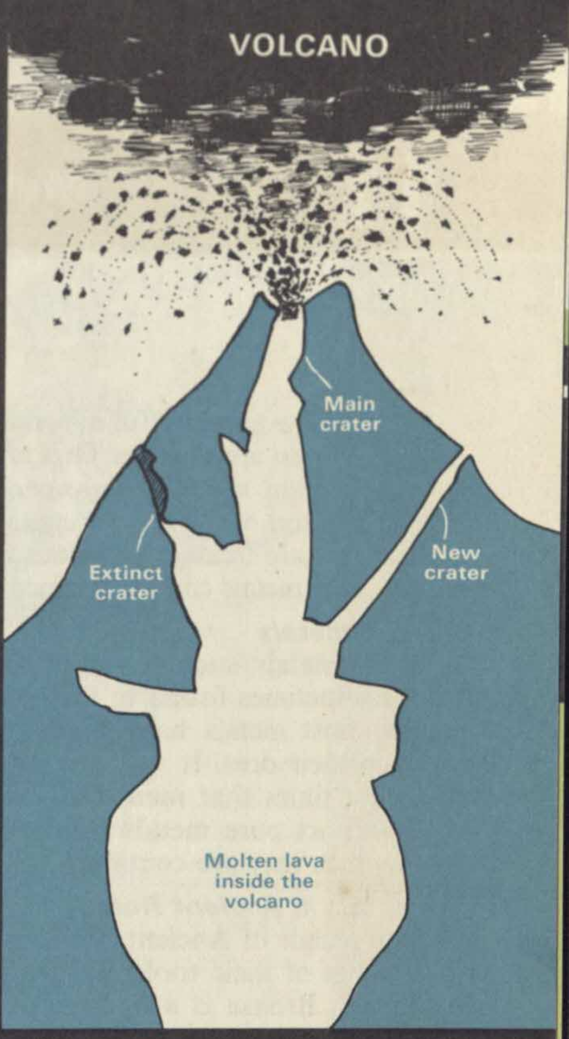
Loaf of bread



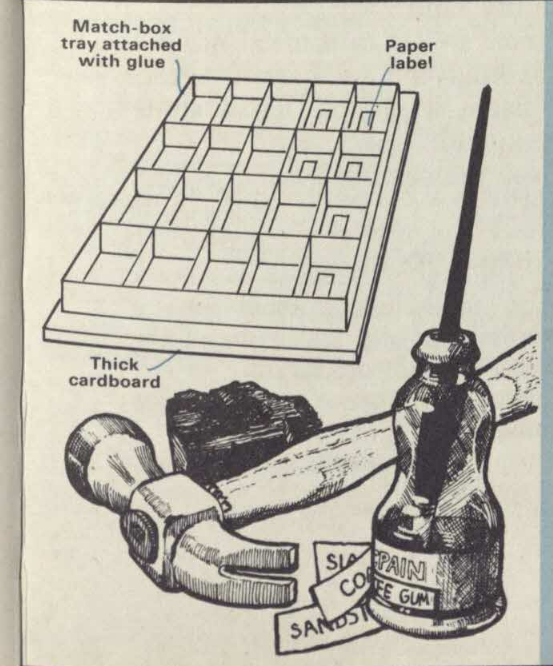
Section of the earth

The earth's crust

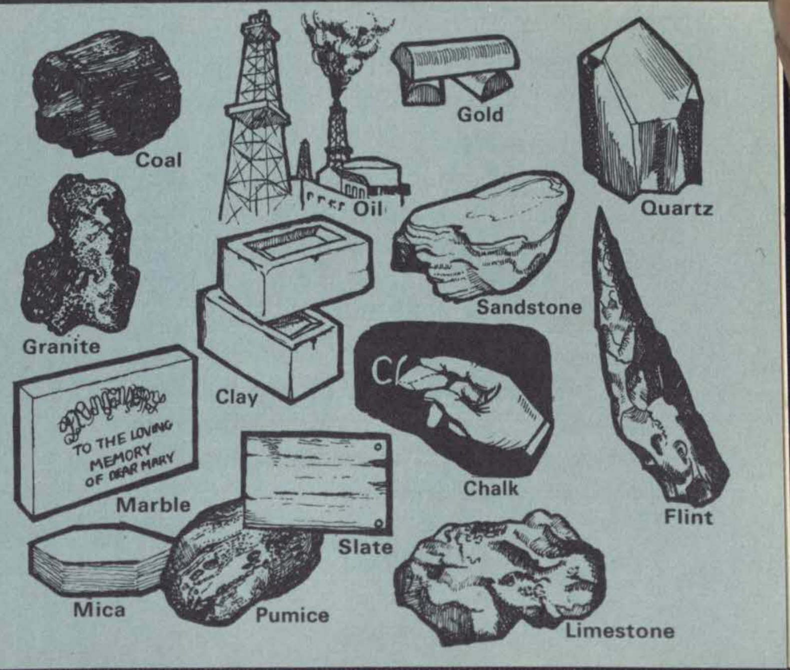




COLLECTING ROCKS



ROCKS AND MINERALS



11 Metals

Ores

Some of the most useful minerals in the earth's crust are the *ores*. Ores are rocks that contain metals. *Iron-stone* is one kind of iron ore. *Tinstone* contains tin. The ores are treated in various ways so that pure metals can be obtained.

Pure metals

A few metals, such as copper and gold, are sometimes found in the pure state, but most metals have to be obtained from their ores. It was not until fairly recent times that men discovered how to extract pure metals from the rocks in which they are contained.

Metals in Ancient Rome

The people of Ancient Rome made the handles of their tools and weapons of *bronze*. Bronze is a mixture of copper and tin. They made their spear heads and sword blades of iron. It was too valuable to be used for anything else. They had not learned how to make fires hot enough to melt iron ore and so extract large quantities of pure iron.

Using metals

Metals have many uses because they are strong and hard-wearing. They can be polished, stretched, beaten, melted and cast into shapes. They are good conductors of heat and electricity.

Alloys

An alloy is a solution of one metal in another. Two or more metals are melted together. When they cool, they become a *solid solution*.

Bronze is an alloy of copper and tin. *Brass* is an alloy of copper and zinc. Brass and bronze are harder than copper. Ordinary *soft solder*, which is used for joining some metals together, is an alloy of tin and lead. It is harder than lead and melts at a lower temperature than does tin.

"Silver" coins contain copper and other metals as well as silver. Silver is too soft and too expensive to be used alone. Copper is put into gold coins and jewellery to make them hard-wearing.

Common metals

Some useful facts about the common metals are given on the page opposite.

Mercury is the only liquid metal.

Copper is soft

Show that copper is a soft metal.

1. Place a length of copper wire on an iron block. Beat the wire with a hammer. The wire is flattened.

2. Tie one end of a copper wire to a strong support. Hold the other end with pliers. Pull the wire very carefully. Notice that the wire stretches.

Making a casting

Use the end of a knife to make a mould in clean dry sand.

Put some solder in a metal lid. Use tongs to hold the lid over a bunsen burner flame. Pour the liquid solder into the mould.

Remove the casting when it is hard and cold.

MORE THINGS TO DO

1. Write one sentence about each of these words in a way which shows that you know what the word means.

Ore; bronze; alloy; solution; brass; solder; casting.

2. Copy the **"Common Metals"** table shown opposite.

Metals

The people of Ancient Rome made their tools and weapons of bronze.

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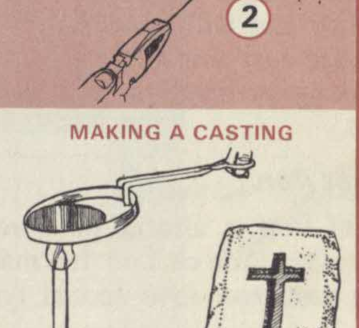
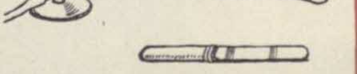
COMMON METALS

Aluminium	Silver-white, tough and light in weight.	Pots and pans, foil and aeroplane parts.
Copper	Red, soft, tough and heavy. Good conductor of heat and electricity.	Electricity cables and contacts and pots and pans.
Gold	Yellow, soft, shiny, heavy and precious.	Coins, ornaments and jewellery.
Iron	Dull-white, hard, tough and heavy. Rusts.	Motor-cars, ships, bridges, cans, tools, weapons and machines.
Lead	Silver-white, soft and very heavy.	Plates of car batteries, roofing, water pipes and solder.
Magnesium	White, soft and light in weight. Good conductor of electricity. Burns easily.	"Flashlight" photography and fireworks.
Mercury (quick silver)	Silvery, shiny, liquid and very heavy. Good conductor of electricity.	Barometers and thermometers.
Silver	White, soft, shiny and precious.	Coins, ornaments and jewellery.
Steel	White, hard, brittle and heavy. Contains a little carbon.	As for iron. Cutting tools,
Tin	White, shiny and soft.	Foil, tinplate and alloys – bronze and solder.
Zinc	White and brittle.	Paints, galvanising iron and brass.

COPPER IS SOFT



MAKING A CASTING



ALLOYS

Brass

Copper and zinc

Bronze

Copper and tin

Solder

Tin and lead

Coins

Silver, copper and other metals

Jewellery

Gold, copper and other metals

12 Iron and steel

Iron: a very useful metal

Of all the metals, iron is the most useful. It is strong, tough, hard-wearing and cheap. All sorts of things are made from iron. In fact, there is really no end to the number of things that can be made from iron.

Steel, which is very hard and is used for making such things as cutting tools, is iron that contains a little *carbon*.

The production of iron and steel

Iron is extracted from its ores in a *blast furnace*. A blast furnace is a tall steel tower. The furnace is filled with a mixture of *coke*, *limestone* and *iron ore*, and, then, the mixture is ignited. The inside of the blast furnace becomes very hot. Molten iron sinks to the bottom of the furnace and, from time to time, it is allowed to run out into sand moulds.

The stages in the production of iron and steel are shown opposite. Notice that scrap is sent to the furnaces; iron and steel are used over and over again.

Cast iron

The iron from a blast furnace contains *carbon* and other impurities. It is hard and brittle and will break fairly easily. It is called *cast iron* because it is used for making castings. It is also called *pig-iron*.

Wrought iron

Wrought iron is almost pure iron. It contains very little carbon. It is made by heating cast iron in a special type of furnace. The carbon and other impurities burn away.

Wrought iron is tough and strong. When it is heated, it can be beaten and bent into various shapes. A *blacksmith* uses bars of wrought iron.

Steel

Steel is very hard. It is made by putting just the right amount of carbon into wrought iron. Steel is much harder than wrought iron. Very hard steel contains as much as 1·5 per cent carbon.

Tough iron and hard steel

Show that iron is tough and that steel is hard and brittle.

Use two pairs of pliers to bend a pin. The pin bends because it is made of iron.

Now, in the same way, try to bend a sewing needle. It snaps because it is made of steel.

The heat treatment of steel

Steel is softened and hardened by *heat treatment*.

If steel is heated and then allowed to cool slowly, it becomes softer. This is called *annealing*.

If steel is heated and then cooled quickly by dipping it into oil or water, it becomes harder. This is called *tempering*. Blacksmiths harden knife blades and tools in this way.

MORE THINGS TO DO

1. Draw a blast furnace.
2. Make a list of some of the things that are made from iron and steel.
3. Copy these words.

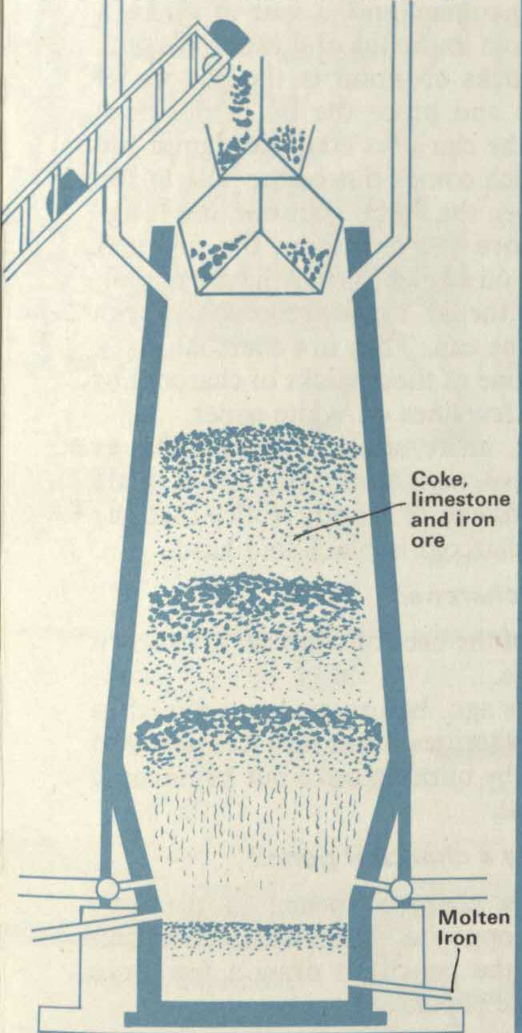
Iron and Steel

Blast furnace; coke; limestone; iron ore; sand moulds; cast iron; pig-iron; wrought iron; blacksmith; carbon; heat treatment; annealing; tempering.

4. Visit an ironworks if you get a chance.

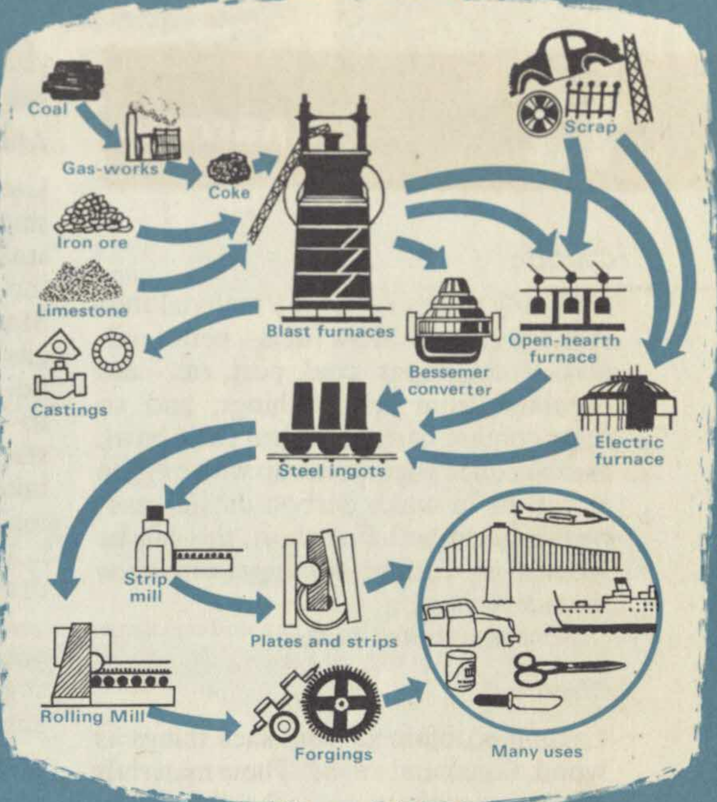
Iron and steel

INSIDE A BLAST FURNACE



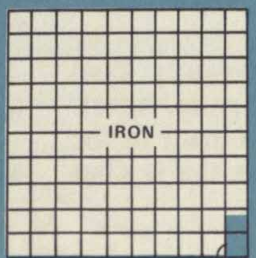
White-hot, molten iron runs out into sand moulds. This is cast iron.

PRODUCTION OF IRON AND STEEL

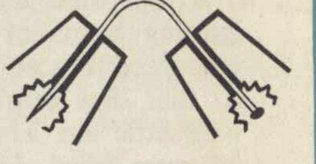


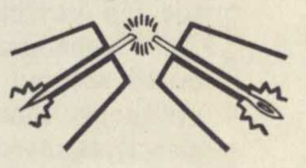
Wrought iron is tough and strong. A blacksmith uses bars of wrought iron.

CARBON IN STEEL



TOUGH IRON AND HARD STEEL


Bending an iron pin


Breaking a steel needle

13 Charcoal

Carbon

All living things contain a material that is called *carbon*. Most fuels – petrol, oil, wax, wood, paper, coal, peat, etc. – are obtained from living things, and so fuels contain carbon. When fuels burn, the carbon in them joins up with oxygen in the air to make carbon dioxide gas; heat is given out. For short, this can be written as, *carbon* + *oxygen* = *carbon dioxide* + *heat*.

Soot is unburnt carbon.

Charcoal

Carbon is obtained from such things as wood, bones and sugar. These materials are heated without air so that the carbon in them cannot join up with oxygen to make carbon dioxide. The materials break up and various gases are given off. Carbon is left behind. This carbon is known as *charcoal*. Charcoal is black and soft.

At one time, charcoal was made by igniting heaps of sticks and logs of wood and then covering them with turf so that they burned slowly and with very little air. The men who did this job were called *charcoal burners*.

Coke

Carbon is also obtained from coal. The carbon from coal is called *coke*. It is an impure kind of carbon. Coke is hard, brittle and grey in colour.

Coke is made at a gas-works. Coal is heated, without air, in a closed retort.

You notice that coke is made in the same way as charcoal. But, this is what you would expect because coal is really wood.

Making charcoal

Use a hammer and a nail to make a small hole in the lid of a can. Put some small sticks of wood in the bottom of the can and place the lid in position. Stand the can in a coal fire. Ignite the gas which comes out of the hole in the lid. When the flame goes out, use tongs to remove the can from the fire and stand it on a brick. When the can is cool, take off the lid. Look at the black sticks inside the can. They are charcoal.

Use one of these sticks of charcoal to draw a few lines on white paper.

Now, make sugar charcoal. Do as you have just done, but use a little sugar instead of wood. Notice that the sugar charcoal is black and hard.

Using charcoal

Some of the uses of charcoal are shown opposite.

Years ago, before coal was mined in large quantities, blast furnaces were not heated by burning coke but by burning charcoal.

Making a charcoal pencil

Make a charcoal pencil in the way shown opposite.

Use the pencil to draw a few lines on white paper.

MORE THINGS TO DO

1. Copy the drawing shown in the black frame opposite.
2. Make a list of the things that contain carbon.
3. Make a list of the uses of charcoal.
4. Use a stick of charcoal to draw a picture on a large sheet of white paper.
5. Make some charcoal shapes in the way shown opposite.

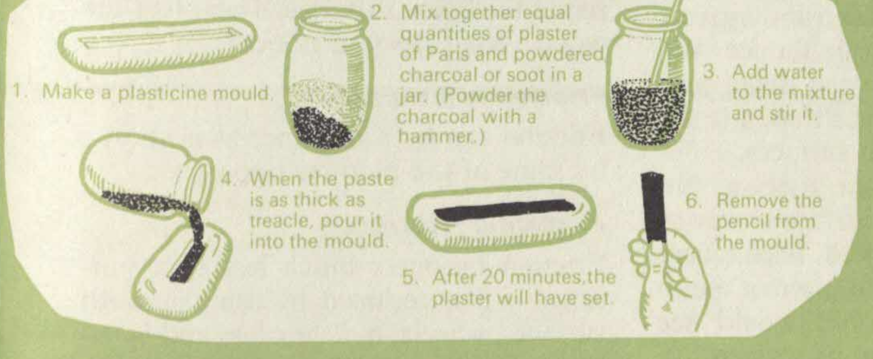
Charcoal

Charcoal burners

Fuels contain carbon

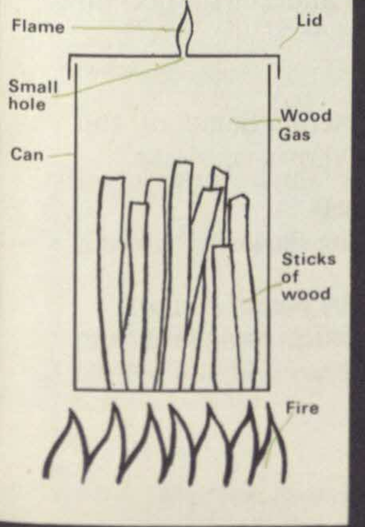
USING CHARCOAL

MAKING A CHARCOAL PENCIL



1. Make a plasticine mould.
2. Mix together equal quantities of plaster of Paris and powdered charcoal or soot in a jar. (Powder the charcoal with a hammer.)
3. Add water to the mixture and stir it.
4. When the paste is as thick as treacle, pour it into the mould.
5. After 20 minutes,the plaster will have set.
6. Remove the pencil from the mould.

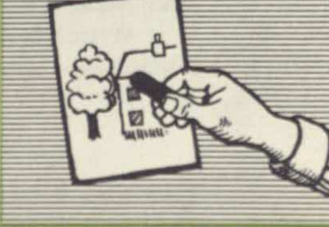
MAKING CHARCOAL



CHARCOAL SHAPES

Cut out a card shape. Rub a stick of charcoal around the edge of the card. Press the card on to a sheet of white paper. Rub the charcoal off the edge of the card on to the paper. Make some other card shapes.

CHARCOAL PICTURE



14 Friction

Rough and smooth surfaces

If a ball is thrown on to a lawn, it bounces and then rolls for some distance before it slows down and comes to a stop. If the ball is thrown, with the same force, on to a frozen lake, it rolls for a greater distance before it stops. This happens because the icy surface of the lake is much smoother than the rough, grassy surface of the lawn.

But, why does the ball come to a stop? Why does it not carry on rolling? It stops because its surface rubs against the surface of the lawn or the ice. We say that the ball is slowed down and made to stop by *friction*. Friction is the rubbing together of two surfaces.

All surfaces give some friction. No matter how smooth a surface seems to be, it is slightly roughened. If you were able to look at a smooth piece of metal under a microscope, you would see "hills" and "valleys" on its surface.

Heat and friction

Friction is turned into heat. When a boy slides down a rope, his hands are blistered by heat from the friction with the rope. A *meteor* is made white-hot by the friction between itself and the air in the atmosphere through which it travels at a tremendous speed. When a saw is in use, its blade becomes hot. Why?

Some friction experiments

1. Tie one end of a string on to the hook of a spring balance. Tie the other end to a block of wood that is resting on a wooden table.

Pull the block along the table. When the block is moving, notice the weight shown by the balance. This is the force that is needed to overcome the friction between the table and the moving block.

2. Hold a smooth wooden board at an angle. Slide various objects, some with rough surfaces and some with smooth surfaces, down the board. The smooth objects move more quickly than the rough objects. Why is this?

3. Use a drawing pin as a small spinning top. Hold the point with your fingers. Give it a quick twist and drop the point on to a smooth table top. The top spins for a time but eventually comes to rest. Why?

4. Rub a piece of wood with sandpaper for a few minutes. Then, feel the wood. What do you notice?

Friction is a nuisance

Friction can be a nuisance as is shown by some of the pictures opposite.

Reducing friction

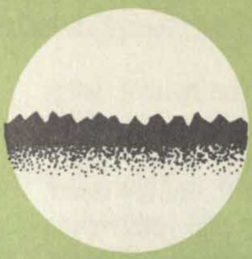
Friction becomes much less of a nuisance if it is reduced by using smooth surfaces, wheels, *ball-bearings* and *lubricants*. Machinery is lubricated with oil, grease and special pastes. Now, turn to page 9. What, do you think, is the purpose of the piece of candle on the bobbin tractor?

Using friction

Friction can be useful. Some of the uses of friction are shown opposite.

MORE THINGS TO DO

1. Copy the drawing shown in the black frame opposite.
2. Make a list of the uses of friction.
3. Write a few sentences about heat from friction.



Smooth surface magnified to show "hills" and "valleys"

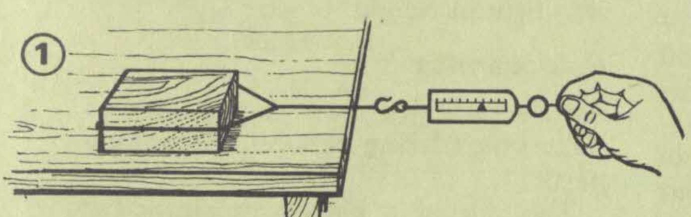
Friction

The ball rolls farther when on the ice than when on the lawn

Friction is the rubbing together of two surfaces

SOME FRICTION EXPERIMENTS

①



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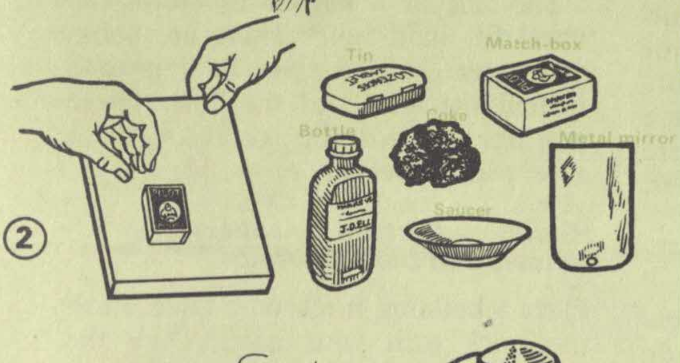

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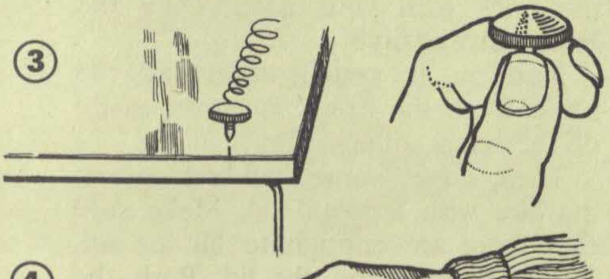
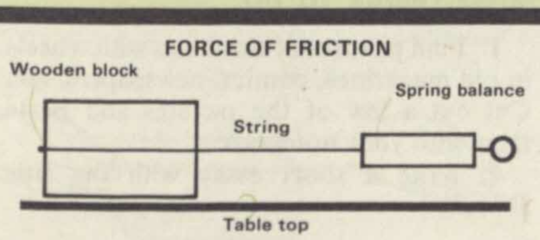


④

FORCE OF FRICTION



A simple drawing for your notebook

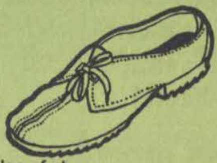
HEAT FROM FRICTION

Boy sliding down a rope

Meteor

Blade of a saw

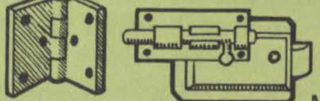
FRICTION IS A NUISANCE



Soles of shoes wear out

Treads on tyres wear away

Old playing cards do not shuffle easily



Rusty hinges, bolts and locks are not moved easily

Moving parts in machinery become hot and damage is done

USING FRICTION

Sand causes friction so that wheels do not skid

Sand on icy roads and railway lines

Brakes

Friction between a brake and a wheel slows the wheel down

Belts

Friction prevents the belts from slipping

Abrasive polishes

Friction rubs away the dirt and grease

Treads grip the road surface

Tyres

Matches are struck on a rough surface

Matches

Friction holds nails in wood

Nails in wood

Have you tried to remove a tight bottle cap with soapy fingers?

Gripping bottle caps tightly

15 Wheels, wheels, wheels!

The age of wheels

People say that we live in the age of machinery. We do depend so much on machines. They do our work, carry us about and entertain us.

It could also be said that we live in the age of wheels because most of our machines contain wheels. Just think about the many different kinds of machines that contain wheels – motor-cars, steam engines, aeroplanes, tape recorders, clocks, watches, etc. There are wheels of all shapes and sizes. Wheels, wheels, wheels!

The wheel: a great invention

The wheel is one of our greatest inventions. It is so useful. What would we do without the wheel?

Before the wheel was invented, loads were carried on the backs of horses, donkeys and other animals or on sledges. Pulling a sledge is very hard work because of the friction between its bottom and the ground.

The people of Ancient Egypt built the Pyramids of heavy rocks. The rocks were moved on *rollers*. These rollers were logs. Only a small part of a log touched the ground and so there was little friction to hinder the movement of the rocks. As a rock moved forward, the logs were taken from behind it and placed in front of it.

Rollers gave men the idea of the wheel. The first cart-wheel was made of a few heavy lumps of wood that were fixed together so that the wheel was fairly round. An *axle* was fitted through a hole in the middle of the wheel. Later on, the Egyptians and Romans used *spoked* wheels on their war chariots. These spoked wheels were not as heavy as cart-wheels.

A modern bicycle wheel has a rubber tyre and metal spokes. It is springy and very light in weight.

Ball-bearings

Ball-bearings are used in machines to reduce the friction between the moving parts.

The axle of a bicycle or motor-car wheel fits in a hole. There are some small steel ball-bearings in a groove around the inside of the hole. These bearings turn with the axle and so there is very little friction.

Reducing friction by rollers, wheels and ball-bearings

Place a building brick on a table. Push the brick with your hand. Does the brick move easily?

Next, put six pencils underneath the brick. Push the brick. It moves easily on the pencil rollers. Why?

Then, cover some ball-bearings or marbles with a metal lid. Make sure that there are enough to fill the lid. Place the brick on the lid. Push the brick. It moves very easily. Why?

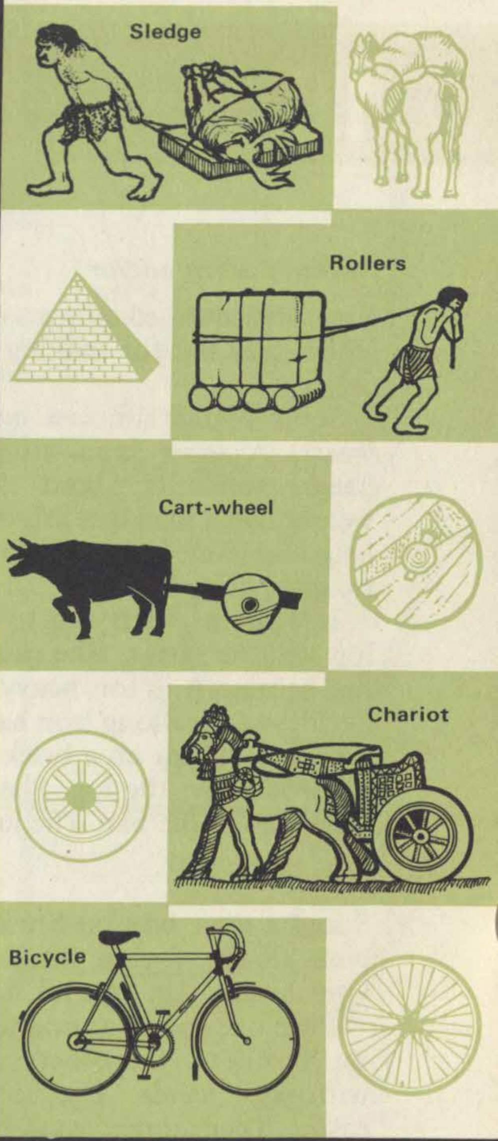
Now, place the brick on a toy truck. Push the truck. It moves easily. Why?

MORE THINGS TO DO

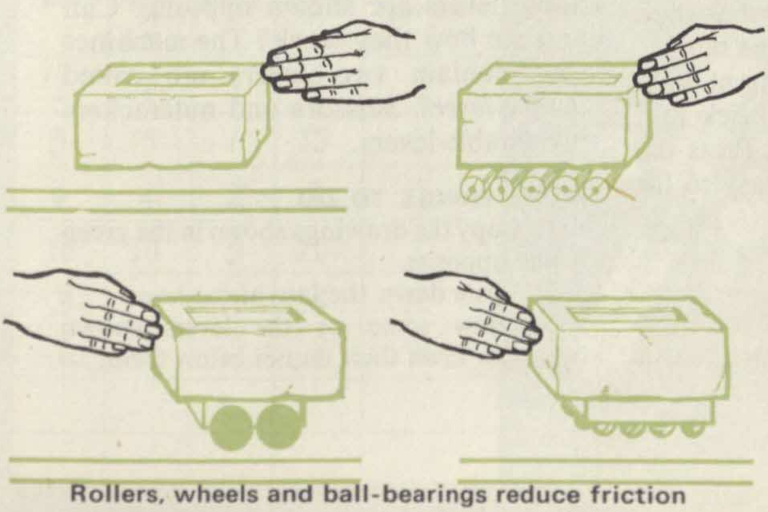
1. Find pictures of machines with wheels in old magazines, comics, newspapers, etc. Cut out a few of the pictures and paste them into your notebook.
2. Write a short essay with the title *Wheels*.

Wheels, wheels, wheels!

THE WHEEL IS A GREAT INVENTION

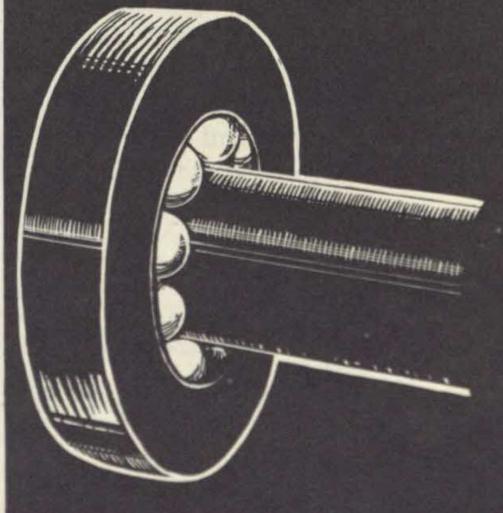


REDUCING FRICTION



Rollers, wheels and ball-bearings reduce friction

BALL-BEARINGS



16 Levers

Making work easier

Men have invented all sorts of machines which they use for making their work easier.

Some of the simplest machines are *levers*. A lever is a strong bar. A *hundredweight* is about the heaviest weight that a man can lift, but, with the help of a lever, he can lift much heavier weights.

Imagine a girl trying to lift a large log with her arms. She cannot lift the log because it is too heavy. Then, she decides to use a long iron bar as a lever. She rests the bar on a brick and pushes one end under the log. She presses the other end of the bar. The log lifts.

Using a lever

Stand a large box on bricks and fill it with stones. Try to lift the box with your hands. Can you lift it?

Push one end of a broom-stick under the box. Pull the other end upwards with your hands. The box lifts quite easily. Then, move your hands down the broom-stick so that they are near to the box. Again, pull the broom-stick upwards. Is it harder to lift the box?

Now, lift the box in a different way. Rest the broom-stick on a brick and push one end under the box. Press the other end downwards. Is it easy to lift the box?

The law of the lever

The heavy weight that is lifted by a lever is called the *load*. The force that is needed to operate the lever is called the *effort*.

In the last experiment, you used a brick as a *turning point* for the lever. You noticed that a small effort on the long arm of the lever moved a large load on the short arm.

With any lever, *the number of times the load is heavier than the effort always equals the number of times the effort arm is longer than the load arm*. Scientists call this the *law of the lever*.

A seesaw

A *seesaw* can be used to show the law of the lever.

Press a pencil on top of two lumps of plasticine in the way shown opposite. Balance a ruler on the pencil.

Place three pennies on one side of the ruler so that they are 5 cm away from the pencil. These pennies are the load. Then, place a single penny on the other side of the ruler so that the ruler balances. This penny is the effort. How many times is the load bigger than the effort? How many times is the effort arm longer than the load arm? Does this agree with the law of the lever?

Balance the seesaw with different numbers of pennies in other positions. Note the distances and make a table in the way shown opposite.

Some levers

Some levers are shown opposite. Can you see how they work? The machines that contain two levers are called *double-levers*. Scissors and nutcrackers are double-levers.

MORE THINGS TO DO

1. Copy the drawings shown in the green frame opposite.
2. Write down the law of the lever.
3. Draw some of the levers shown opposite. Print their names below them.

Levers

L Load position

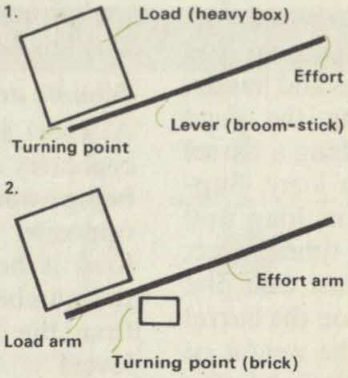
E Effort position

T Turning point

A large log can be lifted very easily if a lever is used

USING A LEVER

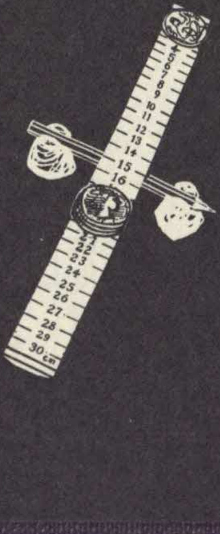
USING A LEVER

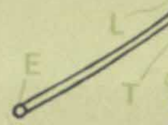


THE LAW OF THE LEVER

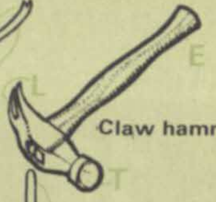
Left-hand side		Right-hand side		Load ÷ effort or effort arm ÷ load arm
Pennies	Distance in cm	Pennies	Distance in cm	
2	4	1	8	2
3	5	1	15	3
4	4	2	8	2
10	10	5	20	2
3	8	1	24	3
?	?	?	?	?

SEESAW

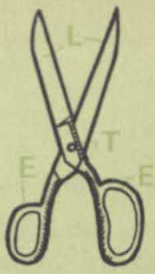




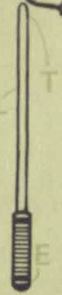
Crow-bar



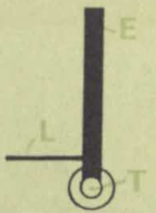
Claw hammer



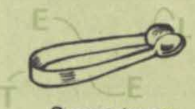
Scissors



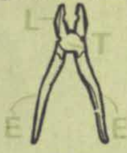
Poker



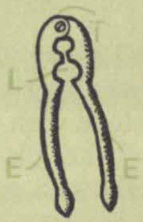
Signal-box lever



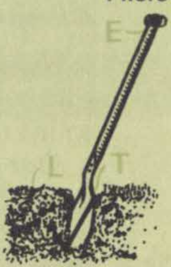
Sugar tongs



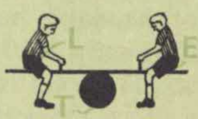
Pliers



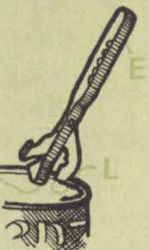
Nutcrackers



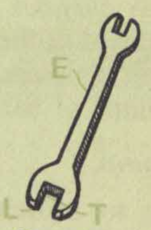
Spade



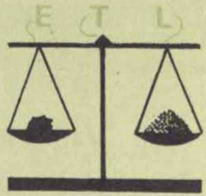
Seesaw



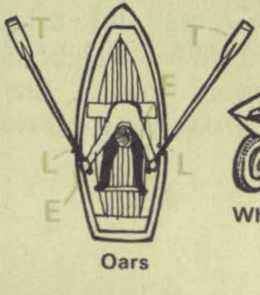
Can-opener



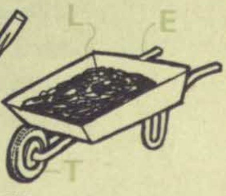
Spanner



Balance



Oars



Wheelbarrow

17 Some simple machines

Some other simple machines

As you know, the lever is one kind of simple machine. Some other simple machines are the *ramp*, the *wedge* and the *wheel and axle*. All these machines make our work easier. They enable us to move heavy loads by small efforts.

Ramps

Ramps are slopes. It is much easier to pull a heavy load up a slope than it is to lift the load with the arms and hands.

One of the pictures on the page opposite shows a man pushing a barrel up a *loading ramp* on to a lorry. Suppose that the ramp is 4 m long and 40 cm high. Its length is 4 times bigger than its height. This means that the weight of the man's hands on the barrel needs to be only 1/10 of the weight of the barrel. The load is 10 times heavier than the effort. Does this remind you of the law of the lever?

Ships' gangways, staircases and road and railway *inclines* are ramps. It is very probable that the heavy rocks used in the Pyramids were moved on rollers up long ramps of earth.

Using a ramp

Use string to attach the hook of a spring balance to a building brick. Lift the brick. What is its weight?

Now, pull the brick up a sloping board. What weight is shown by the balance? This is the effort that is needed to pull the brick up the ramp. It is much less than the weight of the brick.

What does this experiment tell you?

Wedges

Wedges are triangle-shaped blocks that are used for splitting things or lifting heavy loads off the ground.

Knives, chisels, axes, nails, teeth, door-stops and the teeth of saws are wedges. The head of a hammer is held in place by a wedge.

Using a wedge

Fill a large box with heavy stones. Try to lift the box with your hands. Can you do this?

Now, use a mallet to tap a wooden wedge under the bottom of the box. The box lifts easily. Do you know why?

Wheels and axles

A wheel and axle is really a lever that can carry on turning. A wheel and axle being operated by hand is shown opposite. The number of times the load is heavier than the effort equals the number of times the wheel is wider than the axle. Again, the law of the lever!

Winches, *capstans*, drills, egg-whisks and tap handles are wheels and axles.

A model winch

Make a model winch in the way shown opposite.

Use a spring balance to measure the effort that is needed to hold the load.

MORE THINGS TO DO

1. Draw a man pushing a barrel up a loading-ramp.
2. Draw a door-stop.
3. Copy the drawing shown in the black frame opposite.
4. Make separate lists of (a) ramps, (b) wedges and (c) wheels and axles.

Some simple machines

Building the Pyramids

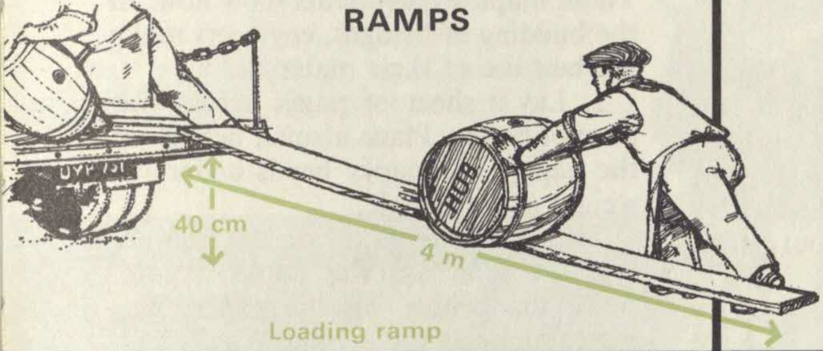
Road incline

Long staircase

Railway incline

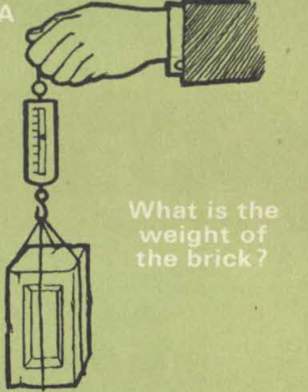
Ship's gangway

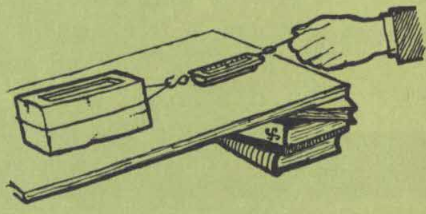
RAMPS



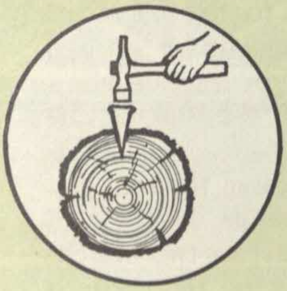
Loading ramp

USING A RAMP


What is the weight of the brick?


What effort is needed to pull the brick up the ramp?

WEDGES

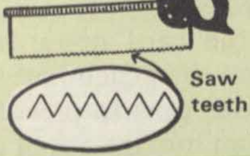


Knife

Chisel

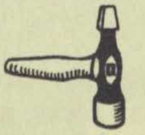
Axe

Nail

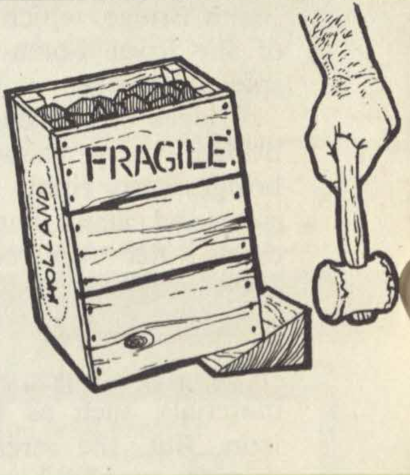

Saw teeth

Tooth

Door-stop


Hammer head

USING A WEDGE



WHEELS AND AXLES

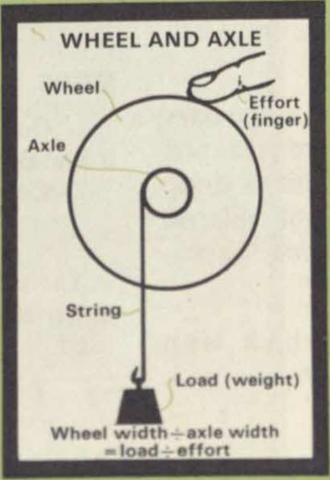
Winch

Capstan

Egg-whisk

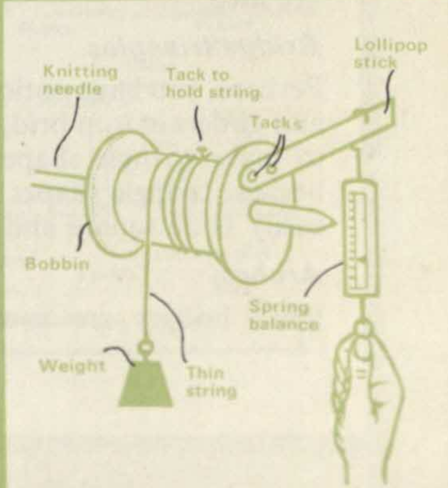
Drill

Water-tap handle


WHEEL AND AXLE

Wheel width ÷ axle width = load ÷ effort

MODEL WINCH



18 Building bridges

The first bridge

A very long time ago, during a violent storm, a tree was blown down by the wind. The tree fell across the banks of a dangerous, swiftly flowing river. A man found this tree. He walked across it in complete safety and without getting wet. This was the first bridge.

Modern bridges

Modern bridges look very different from the tree bridge of long ago. The Forth Bridge, which spans the mouth of the River Forth in Scotland, is a splendid bridge.

Bridges carry roads over railways; bridges carry railways over roads; bridges carry roads and railways over rivers and canals. There are bridges that carry water over roads and railways. Such bridges are called *aqueducts*.

Building bridges

In building bridges, engineers use strong materials, such as bricks, rocks and iron. But, the strength of a bridge depends not only on the kinds of materials that are used but on how they are used.

Bridge triangles

Perhaps, you have noticed that the bars and girders in iron bridges are arranged to make triangle shapes. This is done because triangle shapes do not collapse easily as do square and oblong shapes.

Arches

Brick bridges are usually built with arches. The load on an arched bridge is carried by the sides of its supports. The load on a flat bridge is carried by the tops of its supports.

Some experiments in bridge-building

These simple experiments show how, in the building of bridges, engineers make the best use of their materials.

1. Lay a sheet of paper across two piles of books. Place a small pebble on the paper. The paper bends under the weight of the pebble.

Then, fold the paper, zigzag fashion, and lay it across the books. Again, place the pebble on the paper. The paper supports the pebble. Why?

2. Cut out 7 cardboard strips, each about 15 cm long and 1 cm wide. Use paper fasteners to fix the strips together to make a square and a triangle.

Push the sides of the square. Its shape changes.

Now, push the sides of the triangle. Its shape does not change.

3. Lay a postcard across two match-boxes. Place a pebble on the card. It bends downwards.

Now, bend the card upwards and hold it in place on the match-boxes with drawing pins. Use pins to prevent the match-boxes from moving out of place. Place the pebble on the card, The card does not bend downwards.

MORE THINGS TO DO

1. Copy the drawings shown in the black frame opposite.
2. Copy this sentence.

Building Bridges

The strength of a bridge depends on the materials that are used and how they are used.

Building bridges

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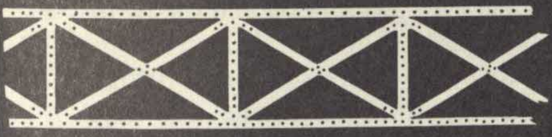
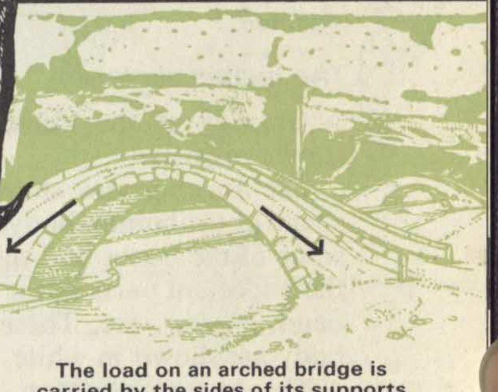
Govt. of West Bengal

BRIDGE TRIANGLES



Triangles do not collapse easily

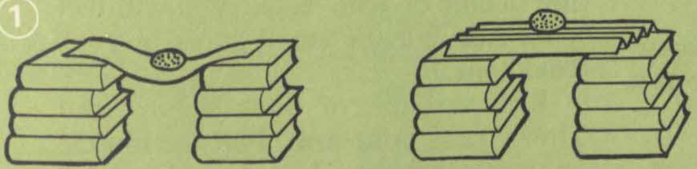
ARCHES



The load on an arched bridge is carried by the sides of its supports

SOME EXPERIMENTS IN BRIDGE BUILDING

①



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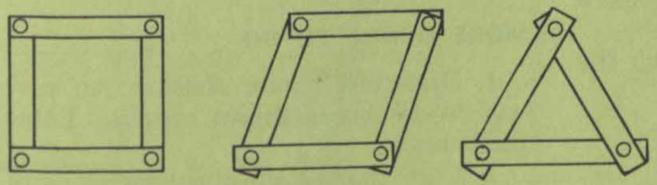

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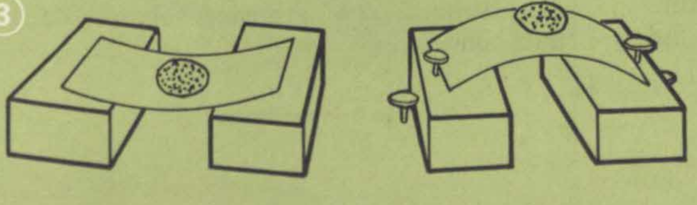
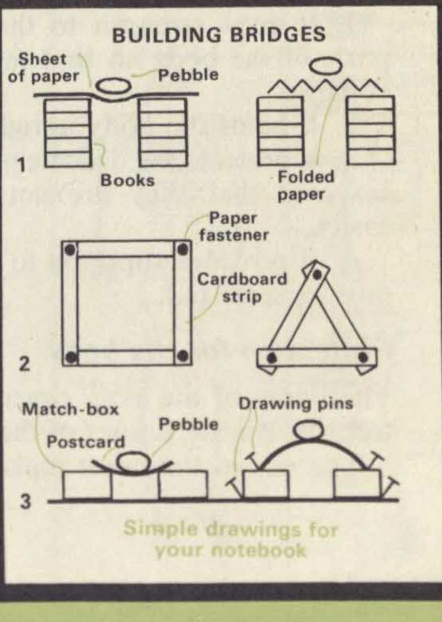




Simple drawings for your notebook

19 The skeleton

Support for your body

As you know, about 7/10 of your body is water. Your flesh is quite soft. Yet, your body is not flabby and floppy. It does not sink to the ground when you walk. Your body is stiff and upright. This is because it is supported by your *skeleton*.

The human skeleton

A drawing of the human skeleton is shown opposite.

The drawing also shows the outline shape of the human body, the names of some of the bones and the positions of the important parts of the body – *heart*, *lungs*, *bladder*, etc. These parts of the body are shown in white.

The human skeleton contains 206 bones of various shapes and sizes.

The work of the skeleton

The skeleton does *four* main jobs.

1. It gives strength to the different parts of the body so that they do not collapse.
2. It holds the body upright.
3. It protects the delicate parts of the body so that they are not damaged easily.
4. It provides supports to which the muscles are fixed.

Protection for the body

The bones of the *skull* cover and protect the delicate tissues of the brain.

The *ribs* in the chest make a "bony cage" that covers and protects the heart and lungs.

The *pelvis*, which is a thick ring of bones, protects the bladder and other delicate parts of the lower body.

Muscles

The body is made to move by muscles. The muscles are fixed to bones by very strong *sinews*.

The muscles in the front and the back of the chest are fixed to the *collar-bones* and *shoulder-blades*. The muscles in the arms are fixed to the *arm-bones*.

The backbone

The *backbone* is not a single bone. It is a long, curved chain of 33 separate bones. Between each bone and the next, there is a pad of gristle. This gristle is called *cartilage*. It is soft and springy and enables the backbone to take sudden shocks. And so, though the backbone is strong and holds the body upright, it also allows the body to turn and move.

Feeling bones and muscles

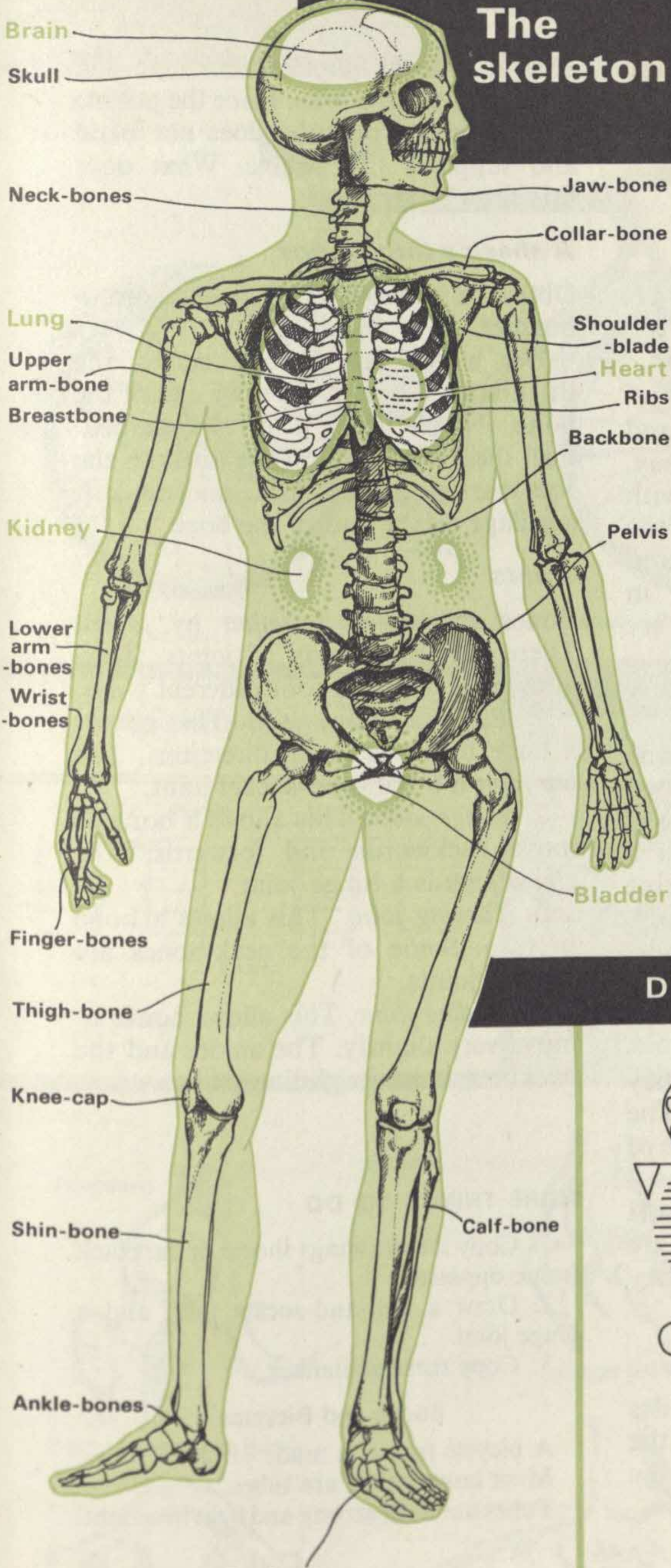
The next time you take a bath, rub your fingers down the side of your chest and the middle of your back. You will feel your ribs and the small bones in your backbone.

Roll up one of your sleeves and slowly raise your arm. Feel the muscle in your upper arm. Is it big and strong?

MORE THINGS TO DO

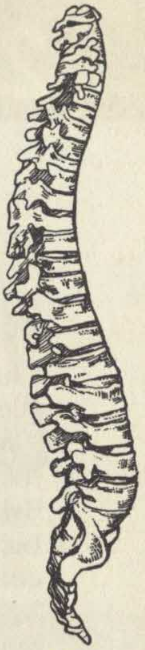
1. Draw the human skeleton. An easy way to do this is shown opposite. Label the bones.
2. Copy the section about the work of the skeleton.
3. Write a few sentences about the backbone.

The skeleton

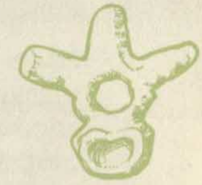


Arm muscles

Backbone

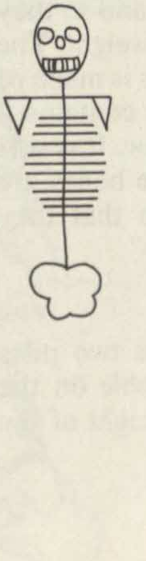


Shoulder-blade

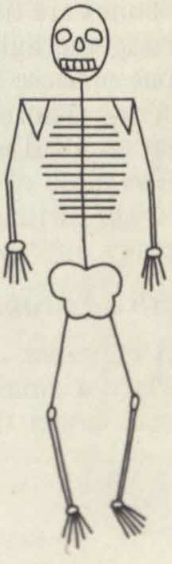


One of the 33 little bones in the backbone.

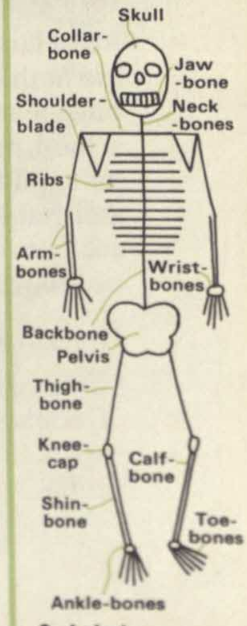
DRAWING THE SKELETON



1. Bones of body



2. Bones of limbs



3. Labels

20 Bones and bicycles

Bones and bicycles

The title of this chapter is "Bones and Bicycles" and you might well say, "What have bones got to do with bicycles?" But, a bicycle frame is the "skeleton" of a bicycle, and bones and bicycle frames have two things in common. Both are strong. Both are light in weight.

A bicycle frame

Have you noticed that a bicycle frame is made of metal tubes? There are two good reasons for this. A metal tube is both strong and light in weight. If a bicycle frame were made of flat strips of metal, they would bend very easily. If the frame were made of solid rods, they would be far too heavy.

Bones

Most large bones are tubes, and so they are both strong and light in weight. The outside of one of these bones is made of a hard material. The inside contains a material that is called *marrow*. It is soft and fatty. The ends of some bones are cushioned with cartilage so that they can move easily on "springs".

The strength of a tube

Lay a sheet of paper across two piles of books. Place a small pebble on the paper. It bends under the weight of the pebble.

Now, roll the paper into a tube and lay it across the books. Place the pebble on the tube. The tube does not bend and supports the pebble. What does this show?

A sheep's thigh-bone

Obtain a sheep's thigh-bone from a butcher.

Use a hacksaw to saw across the thigh-bone. Look at the sawn end of the bone. Notice that it is tube-shaped. Feel the hard bone on the outside, the soft marrow on the inside and the soft cartilage on the end of the bone.

Joints

Bones are joined together by *joints*. There are four kinds of joints. They allow movement in four different ways.

1. *Ball-and-socket joint*. This allows a bone to move in all directions. The *hip joint* is a ball-and-socket joint.
2. *Hinge joint*. This allows a bone to move backwards and forwards. The *elbow joint* is a hinge joint.
3. *Turning joint*. This allows a bone to turn. Some of the neck-bones are turning joints.
4. *Gliding joint*. This allows bones to move very slightly. The ankles and the backbone contain gliding joints.

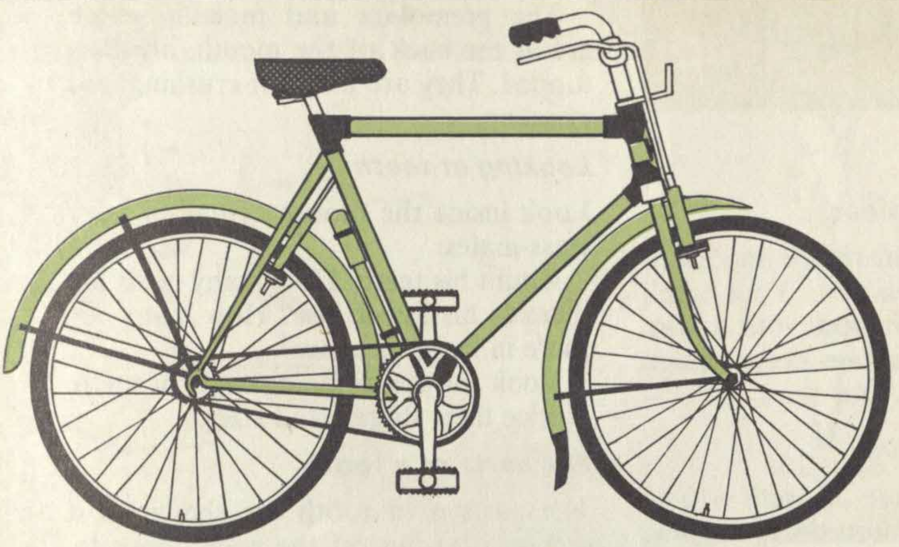
MORE THINGS TO DO

1. Copy the drawings shown in the black frame opposite.
2. Draw a ball-and-socket joint and a hinge joint.
3. Copy these sentences.

Bones and Bicycles

A bicycle frame is made of metal tubes.
Most large bones are tubes.
Tubes are both strong and light in weight.

Bones and bicycles

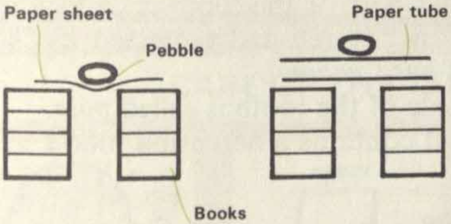


Bicycle frames are made of metal tubes

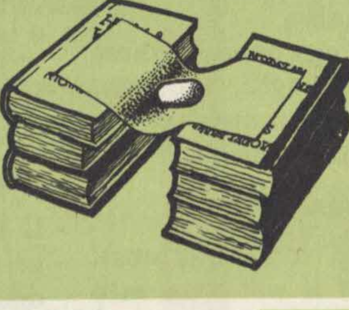
Most large bones are tubes

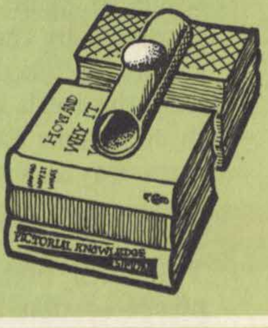
STRENGTH OF A TUBE

STRENGTH OF A TUBE

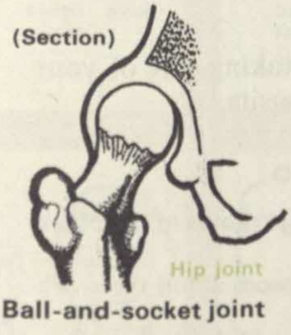


Simple drawings for your notebook

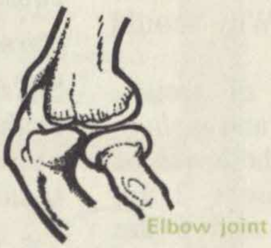




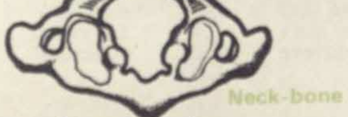
JOINTS



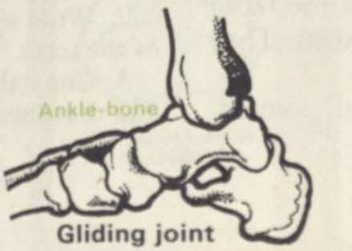
Ball-and-socket joint



Hinge joint

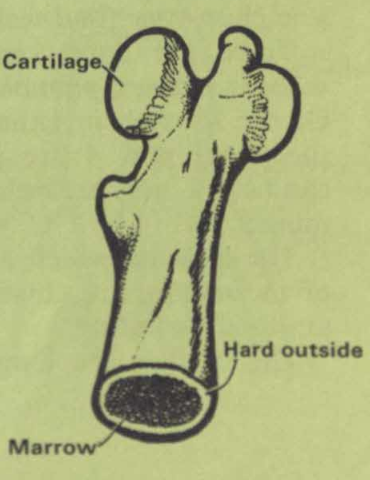


Turning joint



Gliding joint

SHEEP'S THIGH-BONE



21 Teeth

The bones in your head

The bones in your head are important to you for two reasons. Your skull bones cover and protect your brain. Your jaw-bones contain teeth which enable you to chew your food.

The teeth of an adult

An adult should have 32 teeth – 16 in the upper jaw and 16 in the lower jaw.

You do not have 32 teeth because you are not an adult. 4 teeth, called *wisdom teeth*, will not grow through your gums until you are between 17 and 25 years of age. But, apart from this, some of your teeth may have been extracted by the dentist.

Two of the drawings opposite show how the teeth are arranged. The teeth in the upper jaw are arranged in the same way as the teeth in the lower jaw.

The work of the teeth

The teeth break up food into small pieces so that all of it will come into contact with the digestive juices in the mouth and the stomach. Why should you chew your food well?

There are four kinds of teeth – *incisors*, *canines*, *premolars* and *molars*. Of the 16 teeth in either the lower or the upper jaw, 4 are incisors, 2 are canines, 4 are premolars and 6 are molars.

The incisors, which are at the front of the mouth, are chisel-shaped. They are used for biting.

The canines are long and pointed. They are used for tearing.

The premolars and molars, which are at the back of the mouth, are flat-topped. They are used for crushing and grinding.

Looking at teeth

Look inside the mouth of one of your class-mates.

Count his teeth. How many teeth are there in his lower jaw? How many are there in his upper jaw?

Look for the different kinds of teeth. Notice their shapes and sizes.

The parts of a tooth

The parts of a tooth are shown in a section drawing on the page opposite.

The tooth fits in a cavity in the jaw-bone and is held in place by a cement-like substance. The flesh that covers the jaw-bone is called the *gum*.

The solid part of the tooth is called *dentine*. It is covered and protected by a layer of hard *enamel*.

The inside of the tooth is called *pulp*. It is soft. It contains a nerve and blood vessels.

Toothache

If the enamel on a tooth is damaged, germs enter the dentine. The dentine decays and the nerve is exposed. This causes toothache.

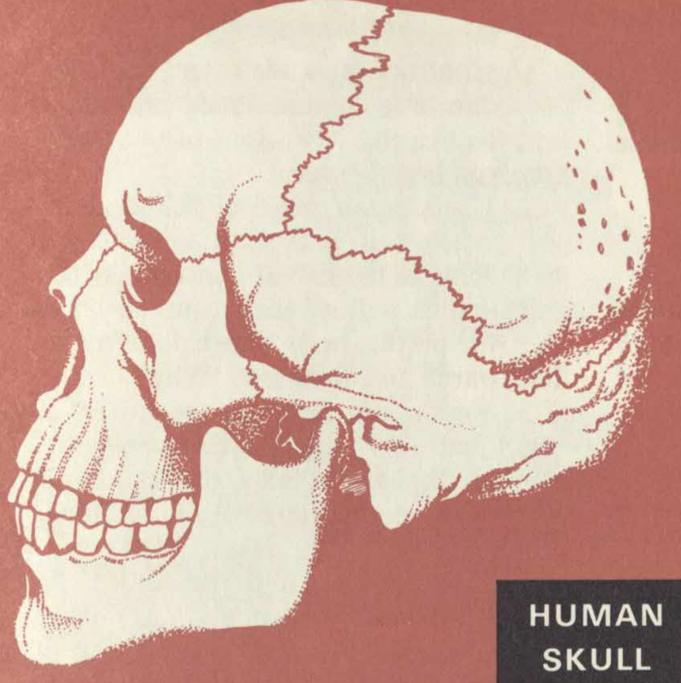
Care of the teeth

Six simple rules for taking care of your teeth are shown opposite.

MORE THINGS TO DO

1. Copy the drawings shown in the black frames opposite.
2. Write a few sentences about the work of the teeth.
3. Copy the **"Care of the Teeth"** rules and drawings.

Teeth

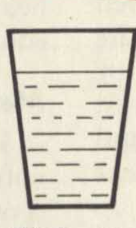


HUMAN SKULL

CARE OF THE TEETH

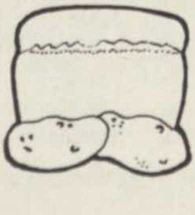
1. Brush your teeth every night.

2. Use an antiseptic toothpaste.

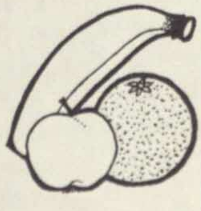


3. Wash your mouth often with an antiseptic mouth-wash.

4. Visit the dentist regularly.

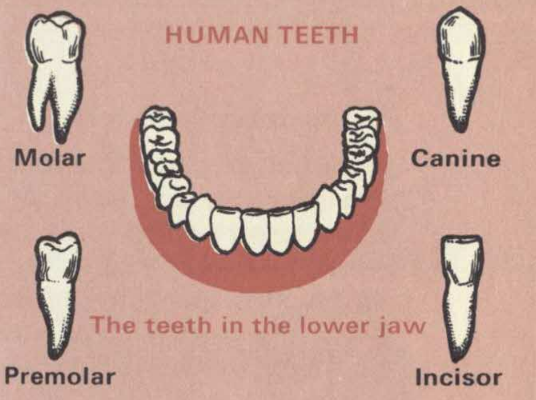


5. Do not eat too much starchy food.



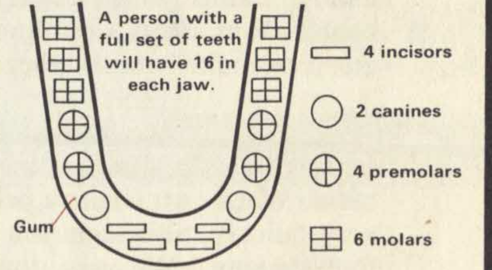
6. Eat plenty of fresh fruit.

HUMAN TEETH



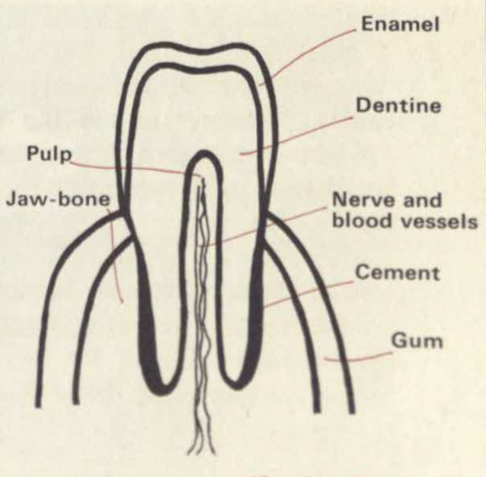
The teeth in the lower jaw

TEETH



A simple drawing for your notebook

PARTS OF A TOOTH



(Section drawing)

22 Sound

The sounds of nature

When you are out in the country during spring or summer, you can hear very many sounds – bird songs, the buzzing of bees and other insects, the rustling of leaves, the splashing of water in a stream, the chirruping of grass-hoppers, etc. These are the sounds of nature.

Making sounds

You make sounds when you clap your hands, stamp your feet, ring a bell, beat a drum, drop a book on the floor, etc. You make sounds when you speak.

What is sound?

But, what is sound? Sound is movement. When you strike a bell, it shakes very quickly, although you cannot see the shaking. We say that the bell *vibrates*. The vibrating bell causes the air around it to vibrate also. The air vibrations, which are called *sound waves*, travel outwards. Some of the sound waves reach your ears, and so you hear the ringing of the bell.

The vocal cords

In your throat, there are two flaps of skin. They are called the *vocal cords*. When you speak, these cords vibrate and so sounds are made.

Feeling the vocal cords

Touch your throat, on the "Adam's apple", with the tip of your forefinger. Now, speak. Can your feel the speech vibrations in your throat?

Showing sound vibrations

1. Hold one end of a steel ruler on the edge of a bench. Pluck the other end. Notice the vibrations of the ruler. Can you hear a sound?

2. Use a small piece of Sellotape to fix a cotton thread to a table-tennis ball. Ring a hand-bell and dangle the table-tennis ball so that it just touches the rim of the bell. The ball bounces backwards and forwards. Why?

3. Rest a postcard on the top of a glass tumbler. Place a few grains of rice on the card. Ring the hand-bell and touch it on the edge of the card. The rice grains jump about. Why?

4. Fold a piece of paper, about the size of a postage stamp, and place it on the *G string* of a violin. Bow the string gently. The paper is thrown off. Why?

Loudness

The loudness of a sound depends on the strength of the vibrations in the object that is making the sound. If a bell is struck gently, a soft sound is heard. If a bell is struck heavily, a loud sound is heard.

Making soft and loud sounds

1. Tap a drum gently. You hear a soft sound. Then, tap the drum heavily. You hear a loud sound.

2. Put a few rice grains on the drum. Tap the drum, first gently and then heavily. What happens to the rice grains?

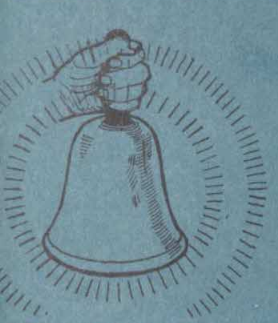
MORE THINGS TO DO

1. Make a freehand drawing of *two* of the **"Showing Sound Vibrations"** experiments.

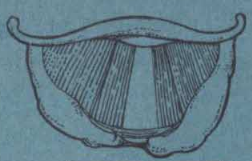
2. Write a few sentences about sound.

3. Make a "musical" wine glass in the way shown opposite. You can do this at home.

Sound



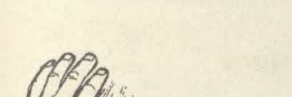
SOUND WAVES IN AIR



VOCAL CORDS

FEELING THE VOCAL CORDS

SHOWING SOUND VIBRATIONS



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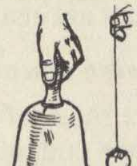

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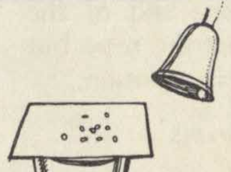

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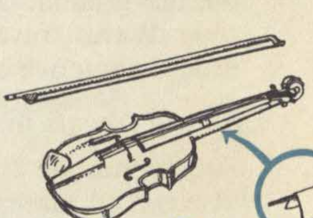
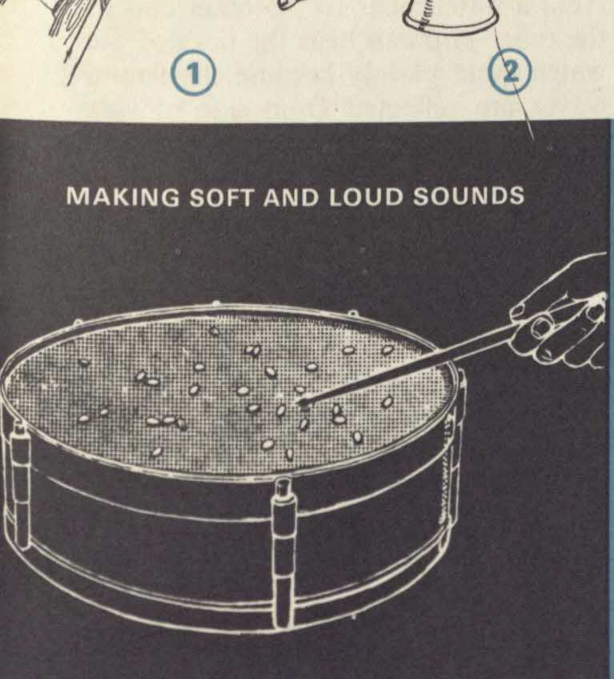
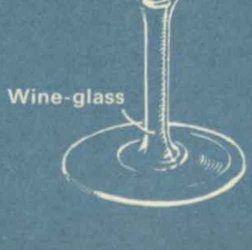


④

MAKING SOFT AND LOUD SOUNDS



"MUSICAL" WINE GLASS



Cut out a cross of thick paper. Place it on top of a wine glass. Bend over the ends of the arms of the cross so that it does not slip off the glass. Moisten the tip of your forefinger and rub it round the outside of the glass. You will hear a humming noise made by the vibrations between the paper and the edge of the glass.

23 How sound travels

Sound waves

When ripples travel across the surface of water, the water does not travel. In the same way, when sound waves travel through air, the air does not travel.

How sound waves travel

1. Drop a small pebble into a dish of water. Notice how the ripples move outwards across the surface of the water.

2. Stand 10 dominoes upright and in a row. Tap the end domino. The force of the tap travels along the row of dominoes. The dominoes fall over but do not move away from their positions.

3. Place a long rope at its full length on the ground. Jerk one end of the rope. Waves travel along the rope but it does not move out of its position.

Sound travels in materials

Sound travels through all materials because all materials can be made to vibrate. But sound cannot travel through an empty space because it contains nothing that can be made to vibrate. People who manage to travel to the moon may find it to be a very silent world. Some scientists believe that the moon has no atmosphere in which sound waves could travel.

Sound travels easier, quicker and farther in solids than it does in air. You can hear a distant train more easily if you stand near to the railway lines. Sound waves travel better through the metal lines than they do through air.

Sound travels in solids

Plug your ears with cotton wool so that you cannot hear the ticks of a watch. Place one end of a ruler on the watch. Hold the other end between your teeth. You can hear the ticks of the watch because the sound waves travel through the ruler and your skull bones into your ears.

The speed of sound

Sound waves travel in air at a speed of 1200 kilometres per hour. Thunder is heard after the lightning flash because light travels very much quicker than sound.

Echoes

If you shout in a long corridor or a tunnel, you will hear a second sound after a short time. The second sound is called an *echo*. Echoes are caused by sound waves being reflected. They are reflected in the same way that a ball bounces against a wall.

Showing sound reflections

Roll a sheet of paper to make a tube. Put one end of the tube to your ear. Hold a watch near to the other end of the tube. You can hear the ticks of the watch quite plainly because the sound waves are reflected from side to side along the inside of the tube.

Using sound reflections

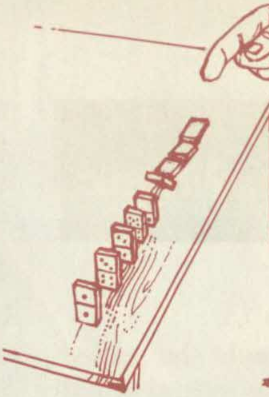
Some of the uses of sound reflections are shown opposite.

MORE THINGS TO DO

1. Draw a *stethoscope* and a *megaphone*.
2. Write a few sentences about echoes.
3. Make a stethoscope and a megaphone in the way shown opposite. You can do this at home.

How sound travels

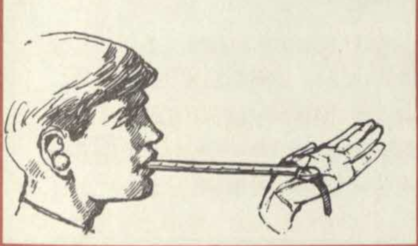
1


2

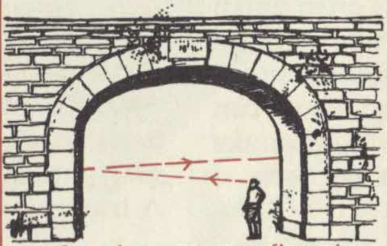
3

HOW SOUND WAVES TRAVEL

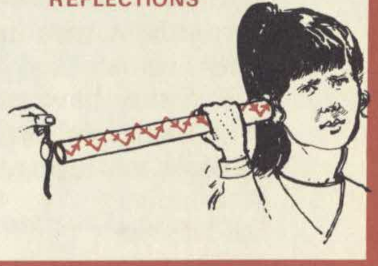
SOUND TRAVELS IN SOLIDS



ECHOES


Sound waves are reflected

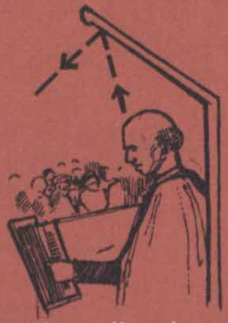
SHOWING SOUND REFLECTIONS



USING SOUND REFLECTIONS

Speaking-tube

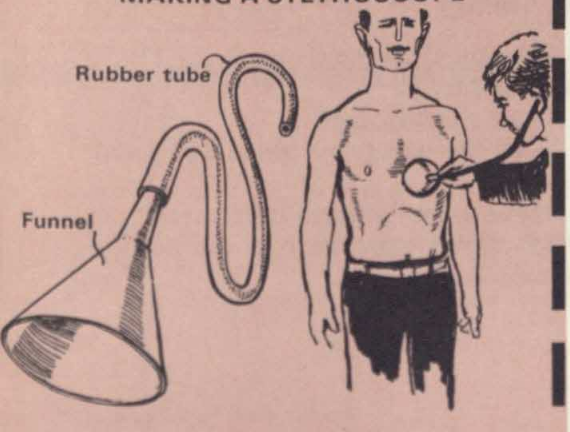
Doctor's stethoscope


Sounding-board

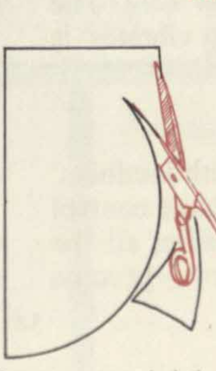
Megaphone

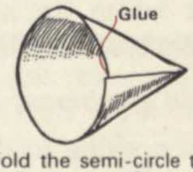
Loud speaker

MAKING A STETHOSCOPE

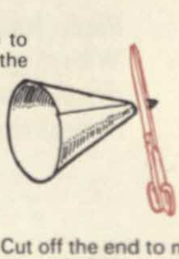


MAKING A MEGAPHONE


1. Cut out a semi-circle from a rectangle of thin card, about 30 cm wide



2. Fold the semi-circle to make a cone. Glue the edges that overlap.


3. Cut off the end to make a mouthpiece.

24 Music

Noise and music

What is music? It could be called "organised noise". A musician would not agree with this, perhaps. But, music and noise are really the same thing. They are both sound.

However, there is a big difference between noise and music. Noise is a mixture of sounds which is often harsh and without meaning, whereas music is pure sounds that have been arranged so that they have meaning. Music can be soothing, sad or joyful. It can make people want to sing, dance or march.

Pure sound and noise

As you know, when an object vibrates, it makes a sound. When one of the wires in a piano is struck, the wire vibrates at a definite speed and a pure sound is heard. When a book drops on to the floor, different parts of the book – and the floor – vibrate at different speeds and a mixture of sounds is heard. This is a noise.

High notes and low notes

If an object vibrates very quickly, it makes a sound that we call a *high note*. If any object vibrates slowly, it makes a sound that we call a *low note*. The speed at which an object vibrates is called its *pitch*.

Pitch and loudness

Pitch has nothing to do with loudness. When you turn up the volume control on a record player or a radio, all the notes, both high and low, become louder. When you turn down the control, all the notes become softer. *Pitch is the speed of the vibrations; loudness is the strength of the vibrations.*

Showing pitch

Use a hammer to drive 8 nails, in a row, in a block of wood in the way shown opposite.

Tap the head of each nail, in turn, with a pencil. The shortest nail vibrates fastest; it makes the note of the highest pitch. The longest nail vibrates slowest; it makes the note of the lowest pitch.

Musical instruments

Some musical instruments are shown opposite. A musical instrument has parts which can be made to vibrate to give pure sounds. A harp has strings. A trumpet has a column of air.

Tuning-forks

Tuning-forks are used by musicians and *piano-tuners*. A tuning-fork gives a definite note.

Sounding a tuning-fork

Tap one of the prongs of a tuning-fork on a cork. A faint sound is heard. Why?

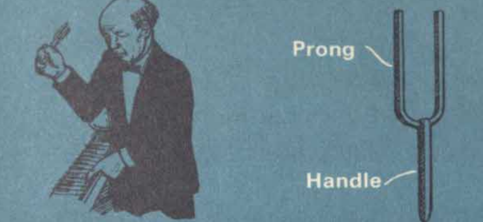
Hold the handle of the fork on a board. The board vibrates too and so the sound is louder.

Now, sound the fork and hold the prongs under the surface of some water in a dish. What do you notice?

MORE THINGS TO DO

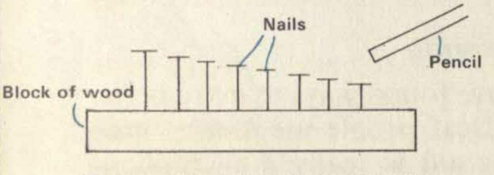
1. Copy the drawing shown in the black frame opposite.
2. Draw a tuning-fork.
3. Copy the paragraph about pitch and loudness.
4. Make some "musical instruments" in the ways shown opposite. You can do this at home.

TUNING-FORK



A middle C tuning-fork vibrates 256 times per second

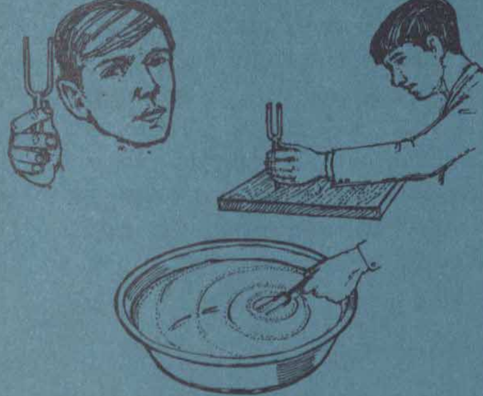
SHOWING PITCH

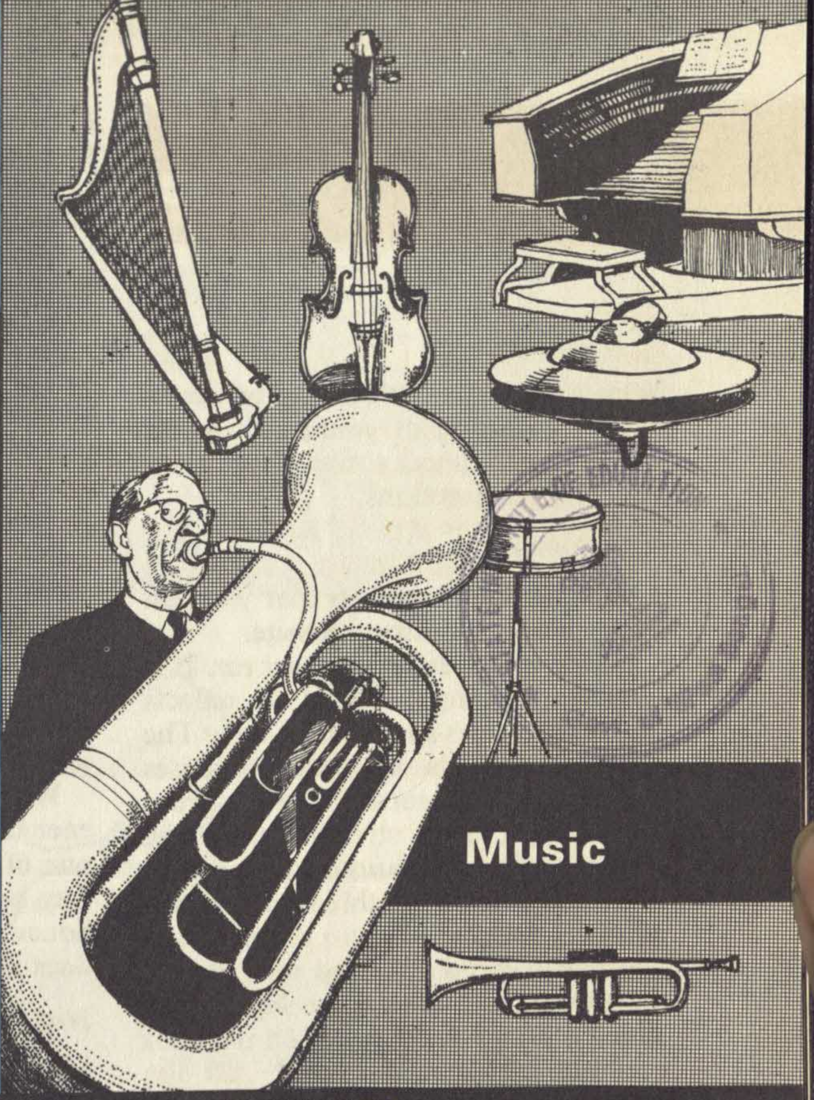


The longest nail gives the lowest note

The shortest nail gives the highest note

SOUNDING A TUNING-FORK

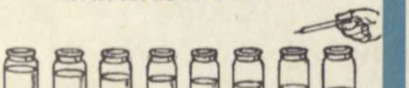




Music

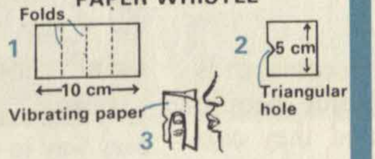
MAKING "MUSICAL INSTRUMENTS"

JAR XYLOPHONE



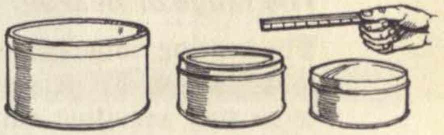
Pour water into 8 jars, each of the same size, so that the water rises in equal "steps". Tap each of the jars, in turn, with a pencil. Which gives the highest note?

PAPER WHISTLE



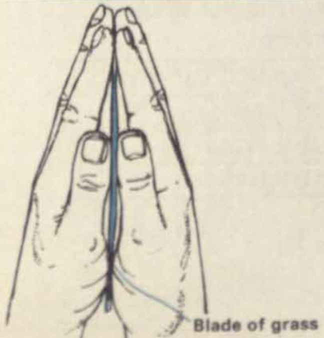
Cut a triangular hole in a folded rectangle of grease-proof paper.

BISCUIT TIN DRUMS



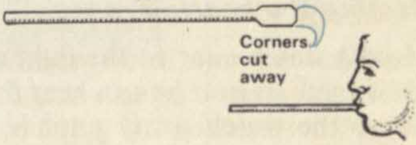
Arrange biscuit tins of various sizes in a row. Strike the tins, in turn, with a ruler. What do you notice?

GRASS WHISTLE



Hold a blade of grass between your thumbs. Blow through the space between your thumbs. Make higher notes by stretching the blade of grass tighter.

MILK STRAW FLUTE



Flatten the end of a milk straw and cut off the corners. Place the flattened end inside your mouth and blow down the straw. The flattened end vibrates and a sound is heard. Use scissors to cut a piece off the end of the straw. The shortened flute will give a higher note.

25 Hearing

Your hearing

How do you hear? You have two ears, one on each side of your head, which enable you to detect sound waves coming from all directions.

A human ear

A human ear, drawn so that you can see its parts, is shown opposite.

Sound waves enter the *outer ear*. It is large and trumpet-shaped. It reflects the sound waves into the *ear-tube*. The air in the ear-tube vibrates and causes the *ear-drum* to vibrate. The ear-drum is a thin skin that is stretched across the ear-tube. The vibrations of the ear-drum are carried by three small bones across the *middle ear* into the *inner ear*. The inner ear is a sound box. It is a coiled tube that contains a liquid. The liquid vibrates and presses on the ends of little nerves which lead into the *auditory nerve*. The auditory nerve carries messages to the brain.

The range of hearing

The hearing range of human ears varies from person to person. Some people have very sensitive ears and they can hear distant sounds. Other people have ears that are not very sensitive; they can only hear sounds that are near.

Testing the hearing range

Hold a watch near to the right ear of a class-mate so that he can hear the ticks. Move the watch away until he is just not able to hear the ticks. Use a tape measure to measure the distance between the ear and the watch.

Then, do this with your class-mate's left ear.

Now, test the hearing range of other class-mates.

Make a table in the way shown opposite.

Better hearing

People have found ways to make better hearing. Deaf people use *hearing aids*. A hearing aid is really a microphone and a tiny *loud speaker* that magnify the sound waves so that they are much louder.

Years ago, before hearing aids had been invented, deaf people used *ear-trumpets*. An ear-trumpet reflects sound waves into the ear.

When a Red Indian was pursued by enemies, he listened for them by placing one of his ears to the ground. In this way, he could hear more distant sounds. Sound travels better in solids than it does in air.

Hearing in animals

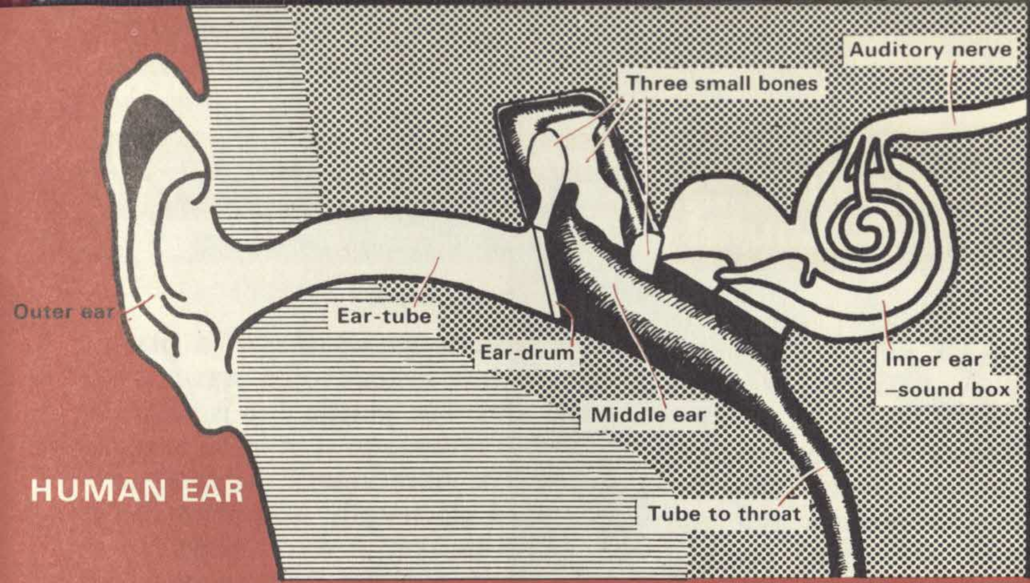
Many animals do not have ears, but they are able to hear in other ways. Some of the ways in which animals hear are shown opposite.

MORE THINGS TO DO

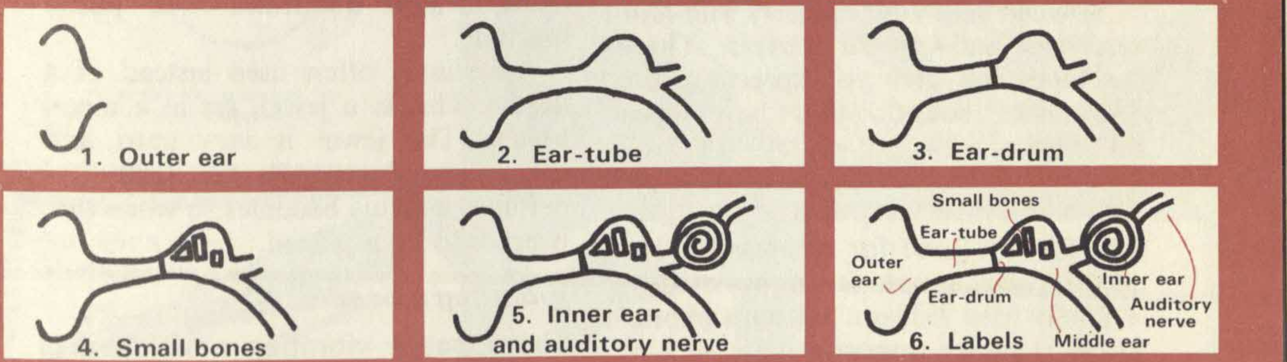
1. Draw the parts of a human ear. An easy way to do this is shown opposite.
2. Copy this table.

HEARING IN ANIMALS	
Mammals	Large, trumpet-shaped outer ears
Frogs	Flat, exposed ear-drums
Fishes	Lateral lines
Earthworms	Sensitive skins
Insects	Sensitive feelers

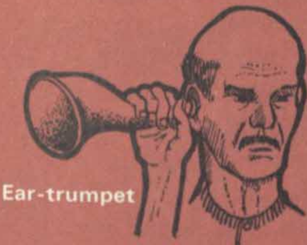
Hearing



DRAWING THE PARTS OF A HUMAN EAR


1. Outer ear
2. Ear-tube
3. Ear-drum
4. Small bones
5. Inner ear and auditory nerve
6. Labels

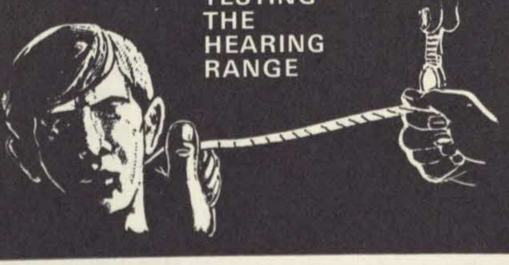
BETTER HEARING


Ear-trumpet

Hearing aid

Indian listening for enemies

TESTING THE HEARING RANGE



HEARING RANGE		
	Distance	
Name	Right	Left
J. Smith	40cm	42 cm
M. Brown	37cm	37 cm

HEARING IN ANIMALS

Mammals

Many mammals have large, trumpet-shaped outer ears which can be turned towards a source of sound. These muscles are powerless in most humans.

Frogs

A frog has a flat, exposed ear-drum on each side of its head.

Fishes

A fish has a lateral line, which is sensitive to sound waves, along each side of its body.

Earthworms

The skin of an earthworm is sensitive to vibrations in the soil.

Insects

The feelers of an insect are sensitive to air vibrations.

26 Recording sound

Sound and memory

Some of the sounds that you hear are stored away in your brain. They become a part of your memory. But, you do not remember other sounds that you hear. They are soon forgotten.

You can help your memory with *tape recorders* and *record players*. These machines will give you speech, music and other sounds that have been recorded.

The phonograph

The first machine for recording sound was the *phonograph*. It was invented by Thomas Alva Edison. Edison's phonograph is shown opposite.

This is how the phonograph worked.

A horn reflected sound waves on to a thin skin that was fixed to a steel needle. The sound waves caused the skin and the needle to vibrate. The needle rested on a roller that was covered with tin foil. When the roller was turned, the point of the vibrating needle made a groove in the tin foil. A soft sound made a shallow groove; a loud sound made a deep groove.

When the roller was turned back, the needle moved up and down in the groove. This made the skin vibrate. The horn magnified the vibrations and so the recorded sounds were heard.

The gramophone

The *gramophone* was invented a few years later than the phonograph. Its inventor was Emil Berliner. A metal disc, coated in wax, was used instead of a roller. A vibrating needle cut a long spiral-shaped groove in the wax.

The record player

In a modern record player, a plastic disc is used instead of a wax-coated metal disc. The plastic disc is called a *record*. It is made to turn by an electric motor. The vibrations of the needle are magnified electrically and reproduced by a loud speaker. A record player does not record sounds. The records are made in large quantities on a special machine.

A *stylus* is often used instead of a needle. This is a jewel, set in a metal holder. The jewel is very hard and thousands of records can be played before the stylus becomes so worn that it needs to be replaced.

Vibrating a needle

Show that a vibrating needle makes sounds.

Place an old, unwanted record (*teacher*: a 78 rev/min record is best for this) on the turn-table of a record player. Switch on the record player.

Hold the point of a sewing needle in the groove on the record. Can you hear faint sounds?

Then, use a match-box as a sound-box and a paper cone as a horn. Two drawings opposite show you how to do this. You can hear louder sounds. Why?

MORE THINGS TO DO

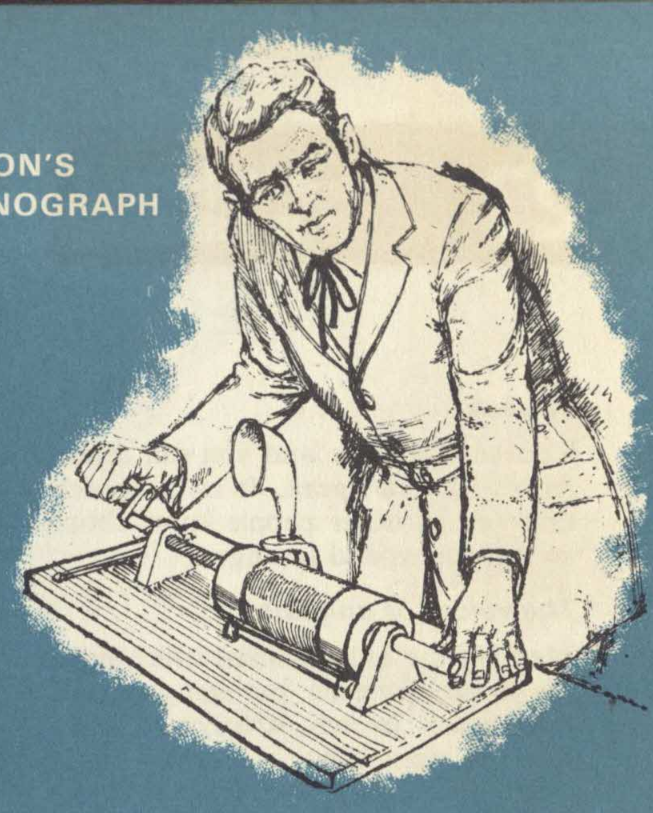
1. Copy the drawing shown in the black frame opposite.

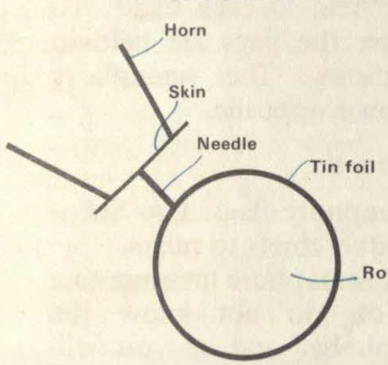
2 Write a few sentences about record players.

3. Use an encyclopedia to find out what you can about Thomas Edison.

Recording sound

EDISON'S PHONOGRAPH





A simple drawing for your notebook

Berliner's Gramophone

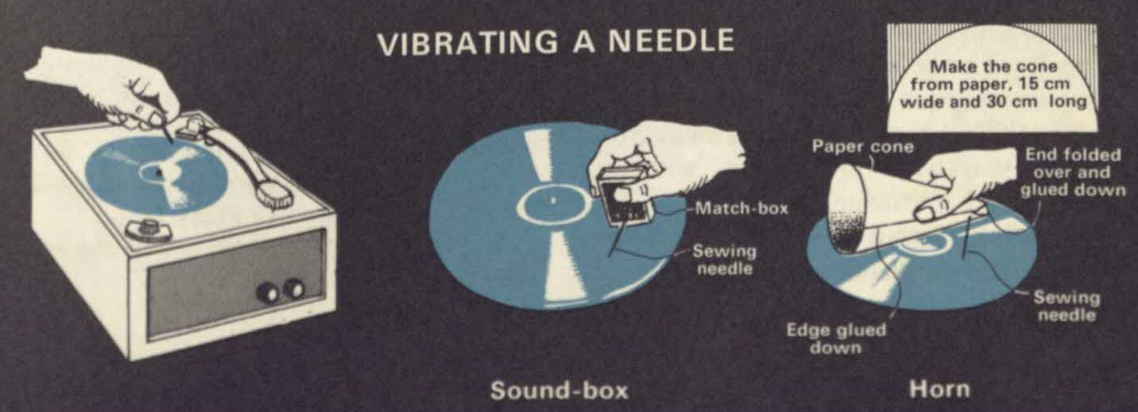
Brain

Record Player

Early Gramophone

Tape Recorder

VIBRATING A NEEDLE



Make the cone from paper, 15 cm wide and 30 cm long

Sound-box

Horn

27 Sending messages

Speech

You have feelings and you can think. Also, you can speak. It is by speech that you let other people know about your thoughts and feelings.

The voices of animals

Men are the only animals which have the power of speech, but many animals have voices by which they can show their feelings. A dog snarls when it is angry; it whines when it is afraid. A cat spits when it is angry; it purrs when it is contented. A monkey screams and chatters in a way that is almost human.

Talking birds

Some birds, like the parrot and the budgerigar, can say words. But, though these birds seem to be able to talk, they do not understand the sounds that they make. They only mimic the people who speak to them. A parrot will say "Pretty Polly" because it has heard someone say "Pretty Polly" over and over again.

Sending messages

If you are with a friend and you want him to know about some of your ideas, you have only to speak. But, what do you do if your friend is living somewhere that is many kilometres away from where you live? Of course, you can send him a message. You can do this by posting a letter or using a telephone.

Men have invented all sorts of ways for sending messages. Some of them are shown opposite.

Semaphore

Semaphore is a system of signalling with two flags, one held in each hand. To send a message, the flags are held in different positions. The semaphore alphabet is shown opposite.

Using semaphore

Make two semaphore flags. Use Sellotape to fix handkerchiefs to rulers.

Send a short semaphore message to a class-mate. You do not know the semaphore alphabet and so you will do this slowly. Look at the semaphore alphabet shown opposite to find out the positions of the flags for each letter. Your class-mate must have the semaphore alphabet in front of him so that he can understand your signals.

Speaking-tubes

Before the invention of the telephone, *speaking-tubes* were used in office buildings. Speaking-tubes are still used on ships.

A speaking-tube works in a simple way. Sound waves are reflected from side to side along the inside of the tube.

Making a speaking-tube

Make a speaking-tube in the way shown opposite.

MORE THINGS TO DO

1. Draw a Red Indian making smoke signals.
2. Make a list of the ways for sending messages.
3. Write a letter to a friend and, in it, tell him (or her) what you know about the voices of animals and talking birds.
4. Write down the semaphore message that is shown opposite.

Sending messages

VOICES OF ANIMALS

SENDING MESSAGES

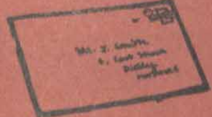
Smoke signals

Relay of runners

Carrier pigeon

Messenger on horseback

Semaphore



Letter

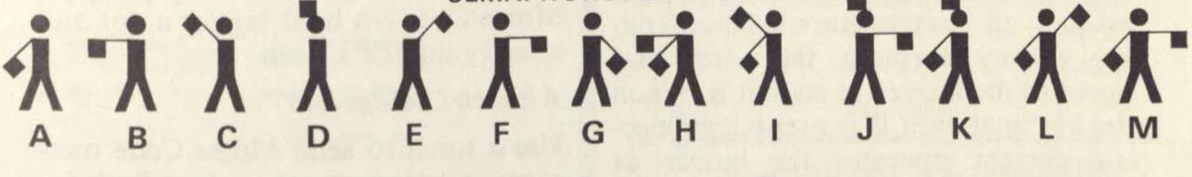
Signal lamp

Speaking-tube

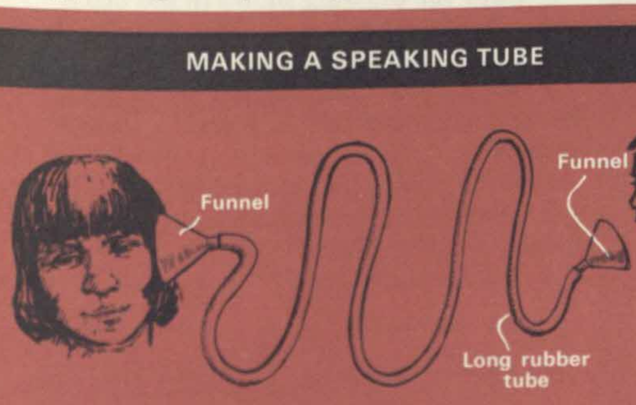
Telephone

Radio

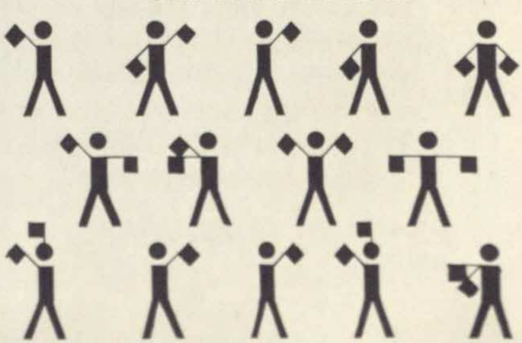
SEMAPHORE ALPHABET



MAKING A SPEAKING TUBE



SEMAPHORE MESSAGE



28 Humming wires

Telegraph wires

Have you ever stood near to a telegraph pole and listened to the humming wires? The wires hum because they are vibrating. They are carrying telegraph and telephone messages.

The telegraph

The telegraph is used to send messages very quickly by electricity.

A buzzer is operated by an electric current which flows through wires when a special type of switch is pressed. The special type of switch is called a *key*. The buzzer works in the same way as an electric bell but it gives a buzz instead of a ring.

A simple telegraph circuit is shown opposite. When the key at station A is pressed, an electric current flows from the battery through the wires and operates the buzzer at station B. When the key at station B is pressed, an electric current operates the buzzer at station A. Can you see how the electric current flows from the batteries to the buzzers?

An earth return

In early telegraph circuits, the earth itself was used instead of one of the connecting wires. This is known as an *earth return*. This meant that less wire was needed, but the circuits were not very good because the earth is a poor conductor of electricity.

Showing an earth return

Use copper wires and paper clips to connect a cycle battery and *headphones* to two large nails in the way shown opposite. Wear the headphones and push the nails, a few metres apart, into damp ground. Make and break contact with one of the nails. You hear "clicks" in the phones. The weak current that is flowing operates headphones but would not light a lamp.

The Morse Code

Telegraph messages are sent in short and long buzzes – the *dots* and *dashes* of the *Morse Code*. This code is named after the man who invented it, Samuel Finley Breeze Morse, an American painter and sculptor. The Morse Code is shown opposite.

A pipe "telegraph"

Ask a class-mate to hold one of his ears against a radiator or a water pipe. Tap the same pipe in another room. Your class-mate hears the taps because the sound waves travel along the pipe.

Now, try to send messages in the Morse Code – a light tap for a dot and a heavy tap for a dash.

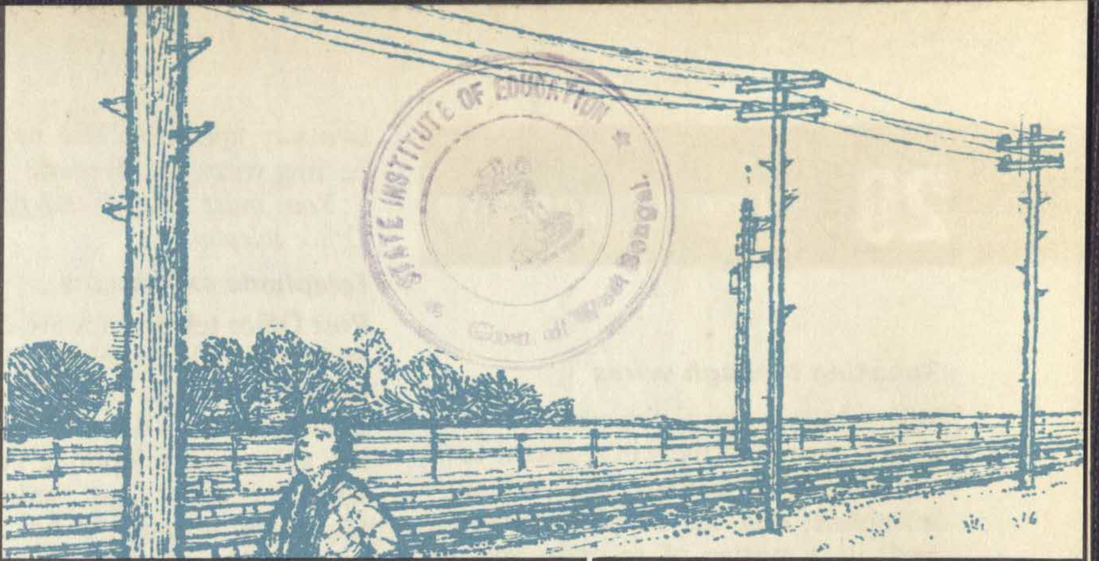
A torch "telegraph"

Use a torch to send Morse Code messages to a class-mate – a short flash for a dot and a long flash for a dash.

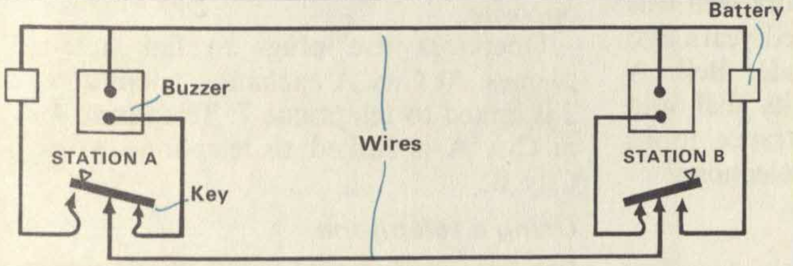
MORE THINGS TO DO

1. Copy the drawing shown in the black frame opposite.
2. Copy the Morse Code.
3. Write down the meanings of the three Morse Code messages, A, B and C, shown opposite.
4. Write your name in the Morse Code.
5. Find out what you can about *telegrams*.

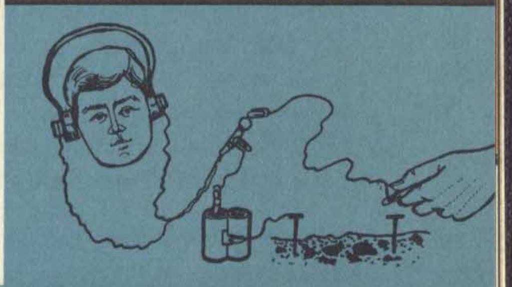
Humming wires



SIMPLE TELEGRAPH CIRCUIT

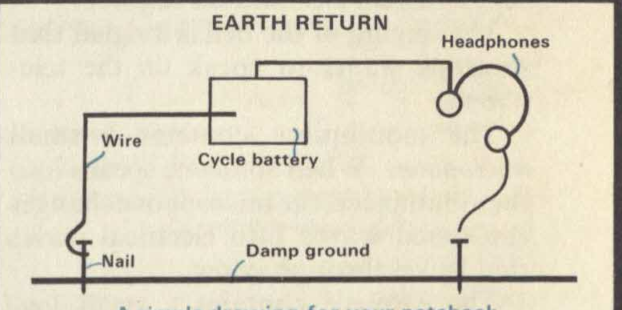


SHOWING AN EARTH RETURN



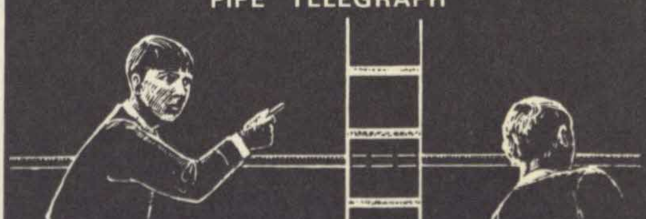
MORSE CODE

A	•—	S	•••
B	—•••	T	—
C	—•—•	U	••—
D	—••	V	•••—
E	•	W	•——
F	••—•	X	—••—
G	——•	Y	—•——
H	••••	Z	——••
I	••	1	•————
J	•———	2	••———
K	—•—	3	•••——
L	•—••	4	••••—
M	——	5	•••••
N	—•	6	—••••
O	———	7	——•••
P	•——•	8	———••
Q	——•—	9	————•
R	•—•	0	—————



A simple drawing for your notebook

PIPE "TELEGRAPH"



THREE MORSE CODE MESSAGES

A • • • — — — • • •

B — — • — — — — — • —
• • — • • — • — • — • —

C • — — — — • • • • •
— — • — — • — —

29 The telephone

Speaking through wires

What do you do if you want to speak to someone who lives in a distant town or village? Of course, you pick up a telephone, dial his telephone number, and, in a matter of seconds, you are speaking to him through wires.

The first telephone to work well was invented about one hundred years ago by a man named Alexander Bell. A modern telephone, with its dial and smooth, streamlined appearance, looks very different from Bell's telephone.

How a telephone works

A telephone has three main parts – a *bell*, a *mouthpiece* and an *earpiece*.

The ringing of the bell is a signal that someone wants to speak on the telephone.

The mouthpiece contains a small *microphone*. When someone speaks into the mouthpiece, the microphone changes the sound waves into electrical waves that travel through wires.

The earpiece contains a small *loud speaker*. The loud speaker changes the electrical waves back into sound waves so that they can be heard.

A telephone circuit

Make a simple telephone circuit in the way shown opposite and use it to speak to a class-mate in another room.

The mouthpieces, the earpieces and the battery are connected in *series*. By this arrangement, the speaker's voice is heard in both earpieces. Also, there is two-way speaking but only two connecting wires are needed.

You must not interfere with Post Office telephones.

Telephone exchanges

Post Office telephones are connected to exchanges where telephones are "put through" to other telephones by switchboard operators or automatic machines. An automatic telephone has a dial on which a caller can select anyone's telephone number. The exchange is usually obtained by dialling "100".

Two telephone exchanges are shown opposite.

Operators use plugs to link telephones. At City A exchange, telephone 2 is linked to telephone 7. Telephone 4 in City A is linked to telephone 3 in City B.

Using a telephone

Perhaps your teacher will show you how to use a telephone.

A "lovers' telephone"

Make a "lovers' telephone" in the way shown opposite. The string should not be more than about 10 metres long.

Ask a class-mate to hold one can to his ear. Pull the string tight and then speak into the other can. Your class-mate will hear your voice faintly.

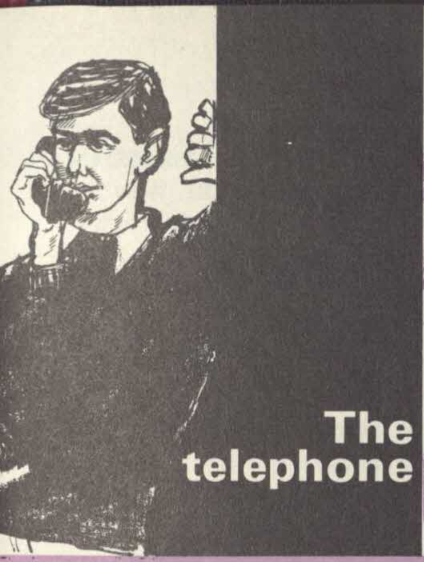
When you speak into a can, the sound waves cause it to vibrate. The vibrations travel along the string to the other can which then vibrates and makes sounds.

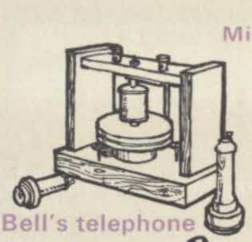
Now, make a "lovers' telephone" with match-boxes instead of cans.

MORE THINGS TO DO

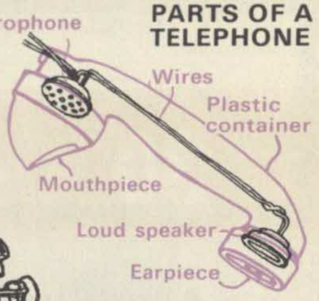
1. Copy the drawing shown in the black frame opposite.
2. Make a freehand drawing of the telephone exchanges shown opposite.

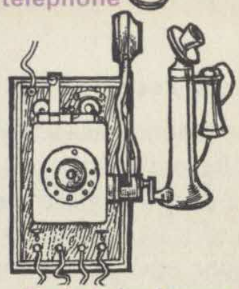
The telephone




Bell's telephone

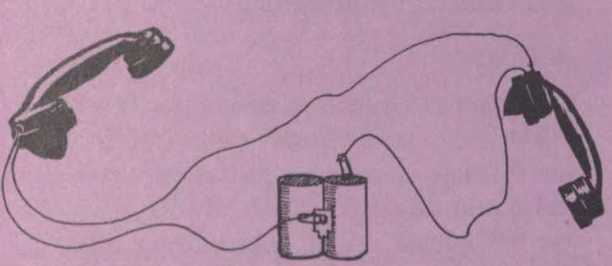
PARTS OF A TELEPHONE

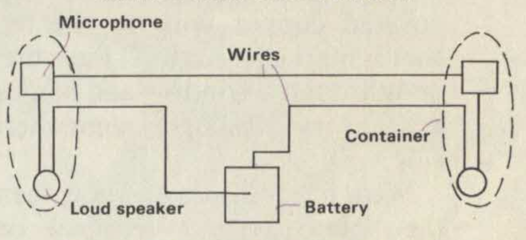



Early telephones

Modern telephone

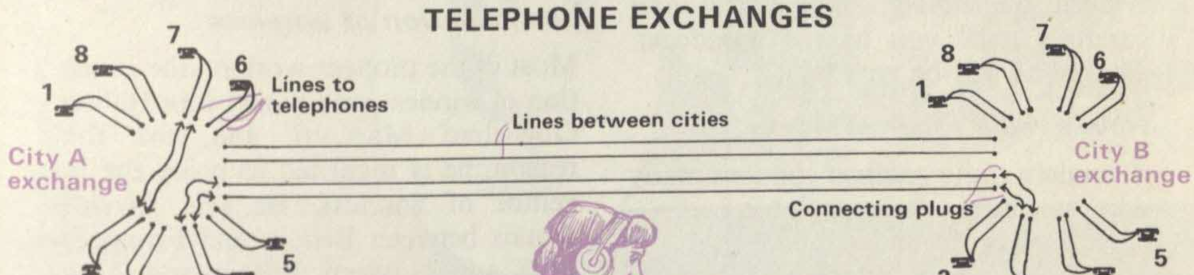
SIMPLE TELEPHONE CIRCUIT



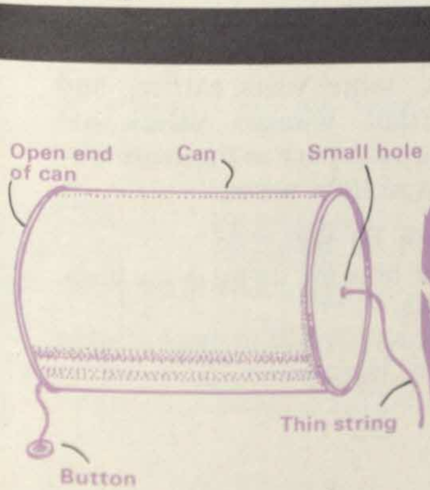


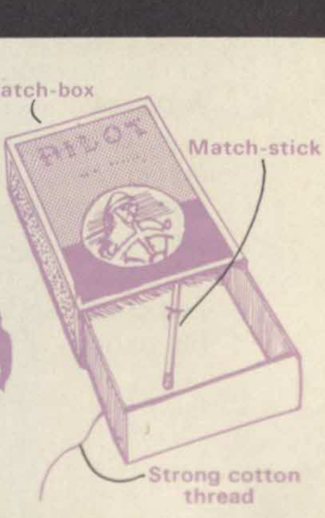
A simple drawing for your notebook

TELEPHONE EXCHANGES



"LOVERS" TELEPHONE





30 A radio receiver

A crystal radio receiver

Perhaps your teacher has a *crystal radio receiver* that he will allow you to use.

Fasten one end of a bare copper wire to the terminal that is marked "Earth". Wrap the other end of the copper wire around a water or a radiator pipe made of metal.

Then, fasten one end of a very long covered copper wire to the terminal that is marked "Aerial". Push the other end through a window and hang up the wire, at its full length, somewhere outside.

Wear headphones and plug them into the "Headphones" terminal on the receiver. (*Teacher*: use *high impedance* headphones.)

Turn the *tuning knob* slowly and carefully until you hear a broadcast. The sound will be very faint.

How a radio receiver works

A modern radio receiver contains many wires and parts. It is much too complicated for you to understand.

But, you can understand how a crystal receiver works because it is very simple and contains very few parts.

Crystal receivers were the first radios to be invented. They do not need batteries.

A crystal receiver has six parts – *aerial*, *earth*, *coil*, *condenser*, *crystal* and *headphones*. The aerial and earth wires pick up the radio waves which are broadcast by radio stations. The coil and condenser are used to select one of the stations. This is done by turning the tuning knob which is fixed to the condenser. The crystal changes the radio waves into ordinary electrical waves. The headphones change the electrical waves into sound waves.

Inside a crystal receiver

It may be possible to remove the back of your teacher's crystal receiver. If he will remove the back, you will be able to examine the inside of the receiver. Look for the coil, the condenser and the crystal. The crystal is not really a crystal. It is a tube-shaped object that contains metals and is covered with some insulating material.

Wireless

Sometimes, a radio is called a *wireless*. "Wireless" is a good name because there are no connecting wires between a radio and a radio station. Radio waves are broadcast by a *transmitter*. They are picked up by a *receiver*.

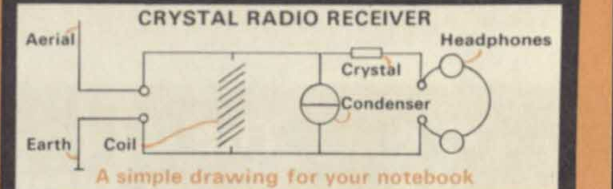
The invention of wireless

Most of the pioneer work on the invention of wireless was done by an Italian, Guglielmo Marconi, and, for that reason, he is regarded as being the inventor of wireless. He sent wireless signals between Britain and France in 1898 and between Britain and Newfoundland in 1901. But, some credit for the invention of wireless should be given to a German, Heinrich Rudolf Hertz, who, some years earlier, had discovered that wireless waves are radiated through space in the same way as are heat and light waves.

MORE THINGS TO DO

1. Copy the drawing shown in the black frame opposite.
2. Use an encyclopedia to find out what you can about Marconi.

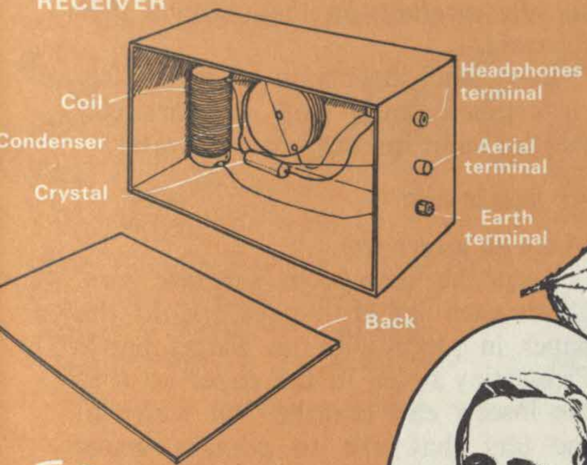
A radio receiver



A simple drawing for your notebook

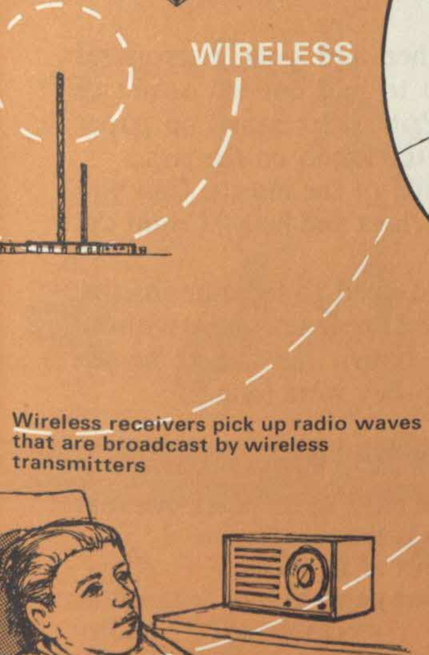
USING A CRYSTAL RADIO RECEIVER

INSIDE A CRYSTAL RECEIVER

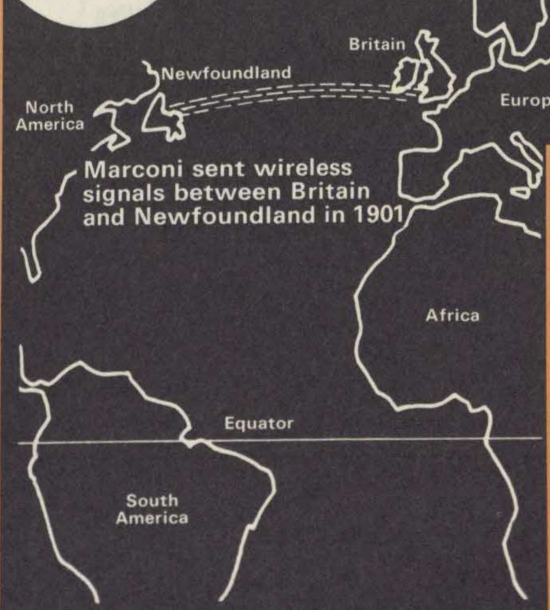


A kite lifts Marconi's aerial into the air

Guglielmo Marconi



Wireless receivers pick up radio waves that are broadcast by wireless transmitters



Marconi sent wireless signals between Britain and Newfoundland in 1901

Marconi sent wireless signals between Britain and France in 1898

31 The insect family

"Creepy-crawlies"

Some people think that all the little creatures that live in the soil and under stones are *insects*. But, many of the "creepy-crawlies" are not insects. Snails, worms, *millipedes*, *centipedes* and spiders are not insects. An insect has 6 legs. A spider has 8 legs. Millipedes and centipedes have many legs. Snails and worms have no legs at all.

What is an insect?

An insect is an animal that has 6 legs and 3 parts to its body – *head*, *chest* and *belly*. The legs are attached to the chest.

There are 2 *feelers* and 2 large *compound eyes* on the head of an insect. The compound eyes contain many small eyes which enable the insect to see in all directions at the same time without any movement of its head.

Many insects have wings. The wings are attached to the chest.

The insect family

The insects are the largest family of animals. Over 600,000 different kinds of insects have been found and named, but, without a doubt, there are very many more. There are insects of all shapes, sizes and colours. Some live on the land, some live in water and many can fly. But, every insect has 6 legs and 3 parts to its body.

Some "creepy-crawlies" are shown opposite. Which of them are insects?

Spiders

Spiders are not insects. A spider has 8 legs, several simple, single eyes, and 2 parts to its body – *chest* and *belly*. The head of a spider is a part of its chest. Spiders have no wings.

Collecting insects

Collect insects of all kinds. Catch water insects and flying insects with a pond net. *Be careful with those insects that can sting.*

Carry the insects in match-boxes, cigar tubes, small cans and jars etc. Put the water insects in jars of water.

An insect zoo

Make an *insect zoo*.

Keep the insects in separate jars. Cover each jar with paper. Hold the paper in place with an elastic band. Pierce tiny holes in the paper so that the insects can breathe. Put water in the jars that are to contain water insects.

Your teacher and your class-mates will help you to find out the names of the insects. Print their names on paper labels. Stick the labels on the jars.

Look at each of the insects. Can you see the head, chest and belly? Count the legs.

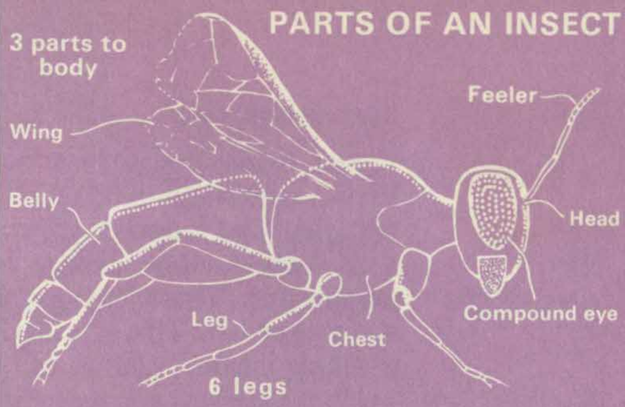
There is no need to feed the insects. They will live for a few days without food. Then, return the insects to the places where they were found.

MORE THINGS TO DO

1. Draw the parts of an insect. An easy way to do this is shown opposite.
2. Make a list of 10 insects.
3. Use tracing paper to copy some of the drawings of "creepy-crawlies" shown opposite. Below each animal, print its name; if it is an insect, label it "insect".

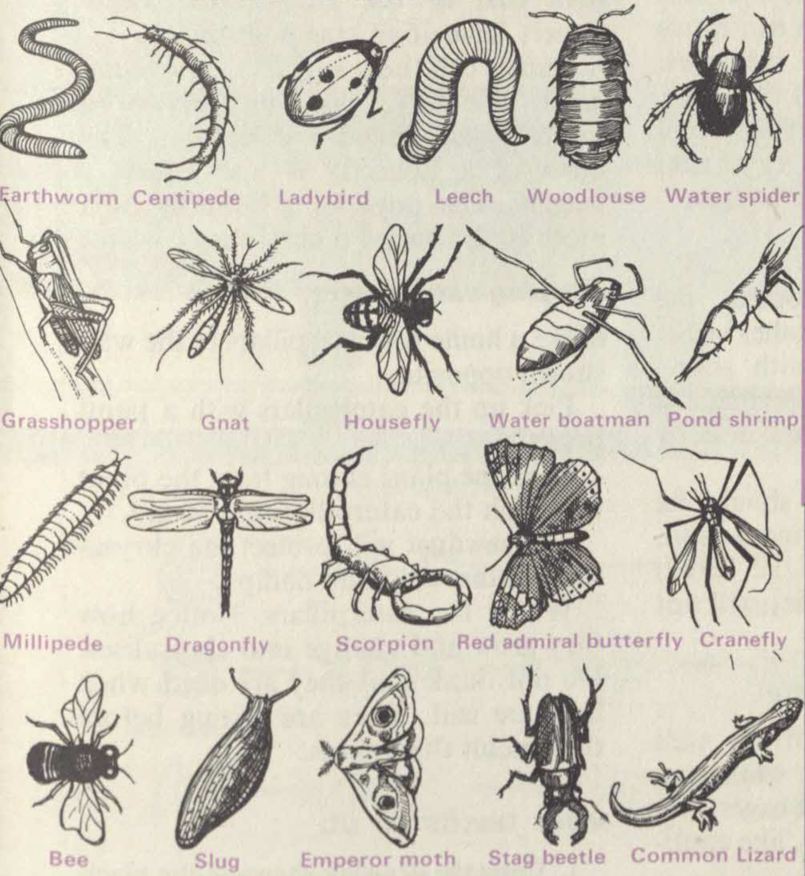
The insect family

PARTS OF AN INSECT

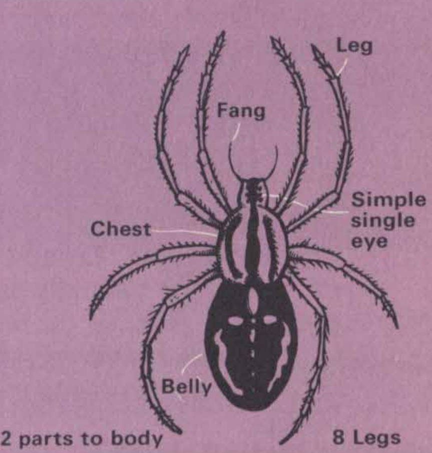


COMPOUND EYES

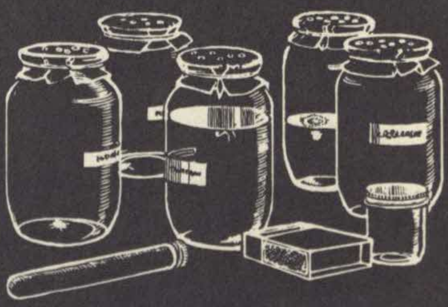
SOME "CREEPY-CRAWLIES"



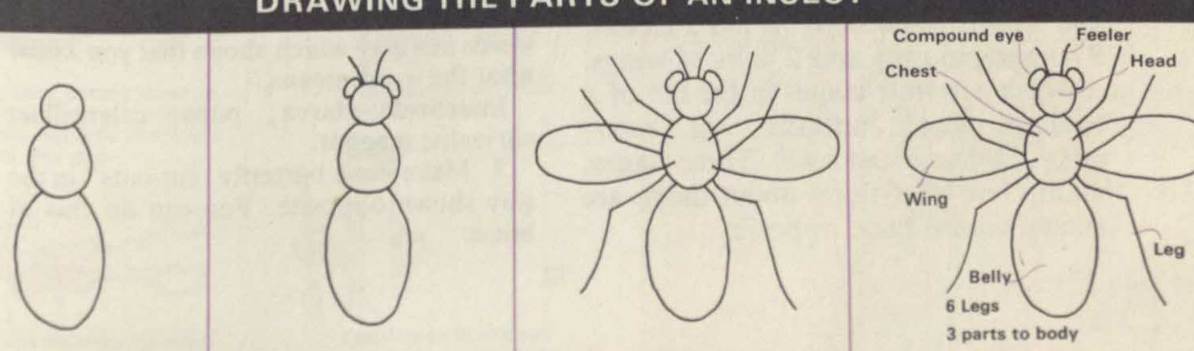
PARTS OF A SPIDER



INSECT ZOO



DRAWING THE PARTS OF AN INSECT



1.

3. Legs and wings

4. Labels

32 The cabbage white butterfly

An insect pest

The *cabbage white butterfly* is a serious insect pest. Its caterpillars eat enormous amounts of the leaves of cabbages, cauliflowers, brussels sprouts, etc. Also, the droppings of the caterpillars spoil the uneaten parts of the leaves so that they are not good for people to eat.

Controlling insect pests

Gardeners and farmers control the cabbage white butterfly and other insect pests by spraying plants with soapy water and *insecticides*. An insecticide is a mixture of chemicals that will destroy insects.

In small gardens, plants should be examined during the egg-laying season. Any insect eggs found on the leaves should be crushed so that they will not have a chance to hatch.

The cabbage white butterfly

The cabbage white butterfly is well named because its wings are white and it feeds on the leaves of cabbages and plants in the cabbage family, like cauliflowers and brussels sprouts.

It is an insect because it has 6 legs and 3 parts to its body. It has 2 feelers, 2 compound eyes and 2 pairs of wings.

There are four stages in the life of a cabbage white butterfly – *egg*, *caterpillar*, *chrysalis* and *adult*. These stages, with a few brief notes about them, are shown on the page opposite.

Metamorphosis

Frogs, toads and newts begin their lives as eggs which hatch out to become tadpoles. The tadpoles grow and, after a few weeks, they change into adult amphibians. These changes are called *metamorphosis*. This is a big word but it simply means "change of body".

Many insects go through a metamorphosis that is even more remarkable than that of the amphibians. These insects have four stages in their lives. Scientists call them *egg*, *larva*, *pupa* and *adult*. The larva of a butterfly or a moth is also called a caterpillar. The larva of a housefly is also called a *maggot*. The pupa of a butterfly or a moth is also called a chrysalis.

Keeping caterpillars

Make a home for caterpillars in the way shown opposite.

Pick up the caterpillars with a paint brush.

Take the plant *cutting* from the plant on which the caterpillars are found.

The sawdust will protect the chrysalises against cold and damp.

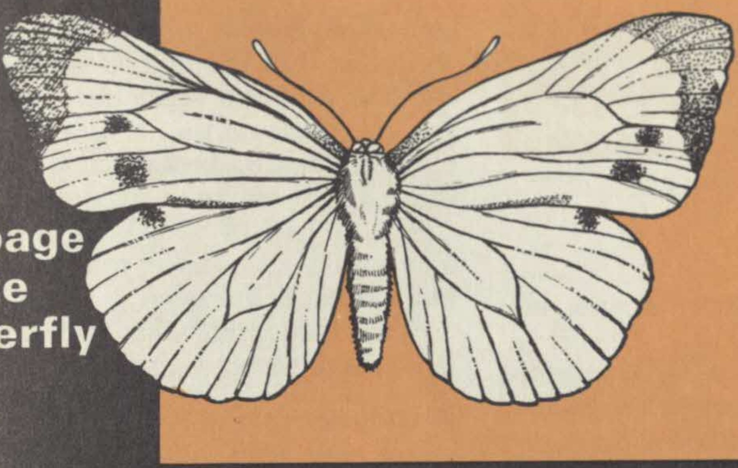
Watch the caterpillars. Notice how they grow and change into chrysalises. Do not think that they are dead when they are still. They are resting before they moult their skins.

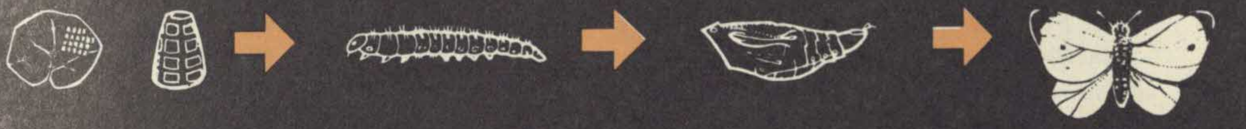
MORE THINGS TO DO

1. Copy the drawing shown in the black frame opposite.
2. Write a sentence about each of these words in a way which shows that you know what the word means.

   Insecticide; larva; pupa; caterpillar; chrysalis; maggot.
3. Make some butterfly "cut-outs" in the way shown opposite. You can do this at home.

The cabbage white butterfly





EGGS

Batches of 20 to 100 eggs are laid on undersides of cabbage or nasturtium leaves in April or May and August or September. Hatch after 10 days.

CATERPILLAR

Blue-green body with 3 yellow stripes. 6 true legs. 8 pro-legs. Eats enormous amounts of food. Moults skin 4 or 5 times. Fully grown after a month.

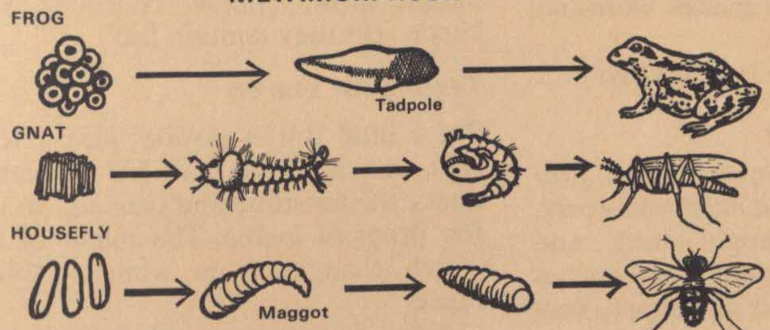
CHRYSALIS

Green with yellow spots. Parts of future butterfly can be seen. Skin splits and adult emerges after 10 to 14 days.

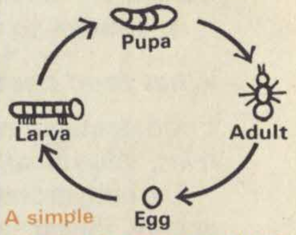
ADULT

3 parts to body. 6 legs. 2 pairs of wings.

METAMORPHOSIS

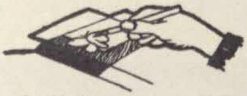


METAMORPHOSIS



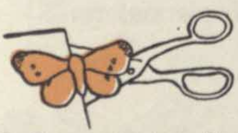
A simple drawing for your notebook

BUTTERFLY "CUT-OUTS"

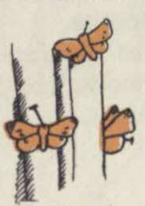


1. Using tracing paper to make many copies of the butterfly at the top of this page.

2. Use crayons to colour the butterflies.

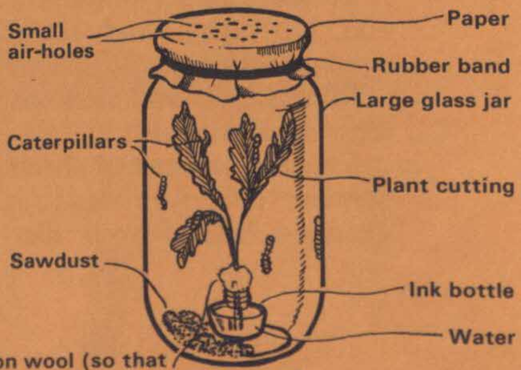


3. Cut out the butterflies.



4. Use pins to fix the butterflies to curtains. Do they look real?

KEEPING CATERPILLARS



Cotton wool (so that caterpillars do not fall into water)

33 Fuel for the body

Fuel and food

Steam, petrol and diesel engines use fuel. The fuel supplies heat and energy. Coal is the fuel for a steam engine. Petrol is the fuel for a petrol engine. What is the fuel for a diesel engine?

Your body must have fuel too. The fuel for your body is the food that you eat. Food supplies you with the energy that you need for work and play. It also supplies you with the heat that you need to keep you warm in cold weather.

What food does

Food does *four* things for you.

1. It supplies heat and energy.
2. It provides material for growth.
3. It repairs and replaces worn-out tissues.
4. It helps to keep you healthy.

What food contains

Food contains *carbohydrates*, *fats*, *proteins*, *mineral salts*, *vitamins* and *water*.

Carbohydrates supply heat and energy. Sugar and starch are carbohydrates. Fats and oils also supply heat and energy. They can be stored away in the tissues of the body.

Proteins supply material for growth and the repair and replacement of worn-out tissues.

Mineral salts and vitamins are necessary for your health.

Vitamins are special chemicals. Food contains only very small amounts of vitamins, but, if your diet does not contain all these vitamins, your health will suffer. For example, if you do not eat fresh fruit and vegetables, you may get a skin disease that is called *scurvy*. Captain Cook prevented scurvy among his sailors by giving them fruit juice.

Almost 7/10 of your body is water. You would soon die if your body did not take enough water.

Some foods and what they do and contain are shown opposite.

Testing for fat

Use the end of a pencil to put a drop of olive oil on a sheet of thin blotting paper. Hold the paper up to the light. You can see a *translucent* stain. "Translucent" means "letting through the light". Light shines through the olive oil stain.

Rub a brazil nut on a sheet of blotting paper. Hold the paper up to the light. You can see a translucent stain. What does this show?

Now, do the same with margarine, butter, meat, cheese, chocolate and bacon. Do they contain fat?

Testing for starch

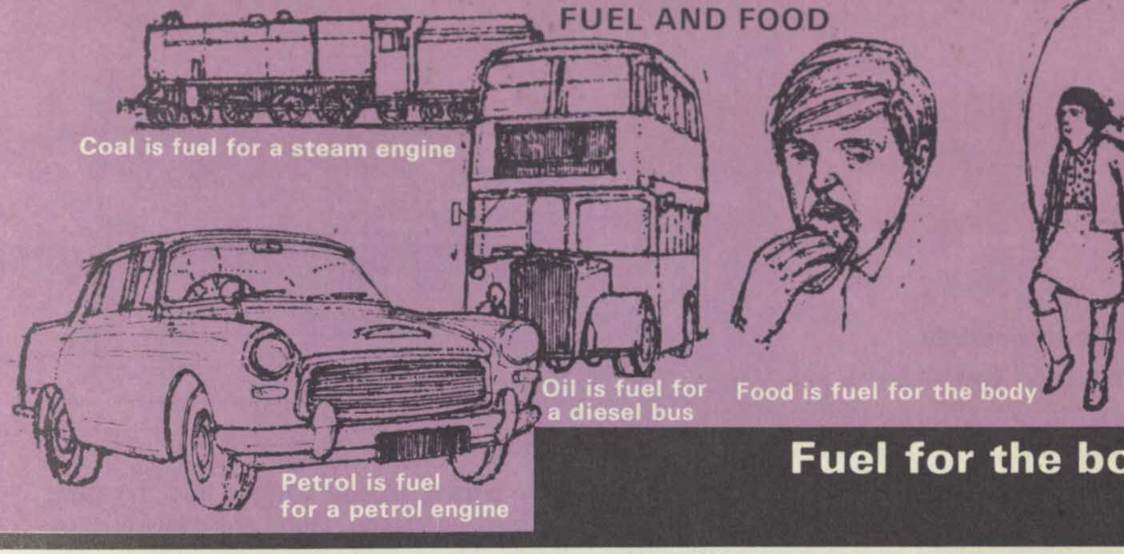
Put a little starch powder into a test-tube that is about half full of water. Shake the test-tube and then add to it a few drops of *iodine*. The colour of the starch changes from white to blue-black.

Now, do the same with flour, breadcrumbs and mashed potato. Do they contain starch?

MORE THINGS TO DO

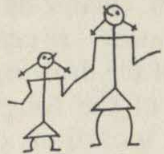
1. Copy the drawings shown in the black frame opposite.
2. Make separate lists of (a) 5 carbohydrate foods, (b) 5 fat foods and (c) 5 protein foods.

Fuel for the body

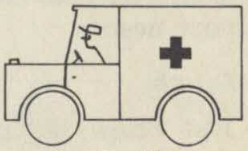

FUEL AND FOOD
Coal is fuel for a steam engine
Oil is fuel for a diesel bus
Food is fuel for the body
Petrol is fuel for a petrol engine

WHAT FOOD DOES

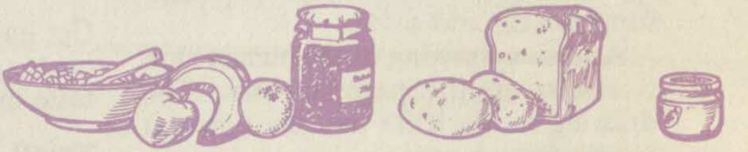
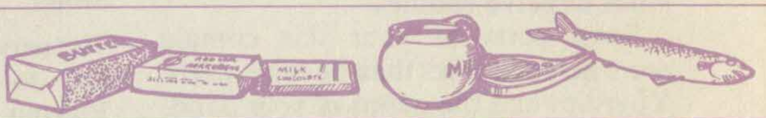
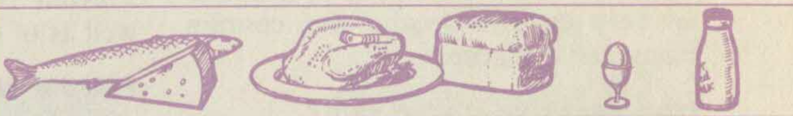
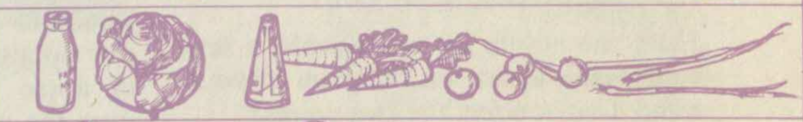
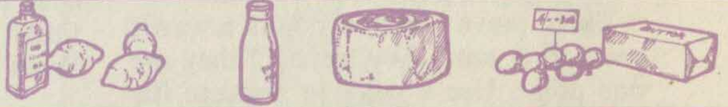
Heat and energy


Growth

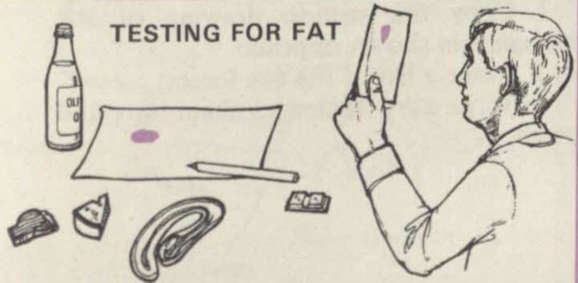
Repairs


Health

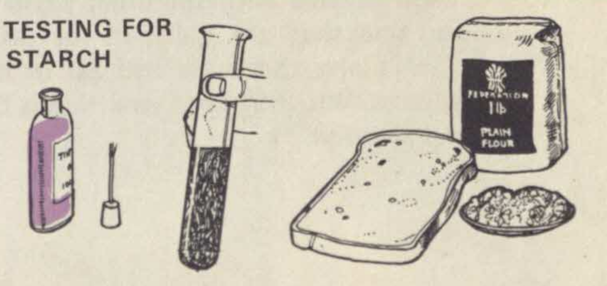
SOME FOODS

CARBOHYDRATES (starch and sugar)	Heat and energy	
FATS (and oils)	Stored heat and energy	
PROTEINS	Growth; repair and replacement of worn-out tissues	
MINERAL SALTS	Health	
VITAMINS	Health	

TESTING FOR FAT



TESTING FOR STARCH



34 Touch, taste and smell

The five senses

How do you know what is happening in the world around you? Of course, you use your *five senses*. Your five senses are *hearing*, *sight*, *touch*, *taste* and *smell*. You hear with your ears, see with your eyes, touch with your skin, taste with your tongue, and smell with your nose.

Touch

Just below the surface of your skin there are small *nerve endings*. Some are sensitive to touch, some to pain and some to heat and cold.

A section drawing of the human skin is shown on the page opposite. The drawing shows hairs and the different kinds of nerve endings.

Some parts of your skin contain more nerve endings than do other parts. Your lips and the palms of your hands are very sensitive because they contain many nerve endings.

How sensitive is your skin?

Hold the points of two pencils, a few centimetres apart, on the palm of your hand. Can you feel the two points?

Then, move the two points towards each other until they feel as if they are one point. Use a ruler to measure the distance between the two pencil points.

Now do this with the other parts of your skin that are given in the table below. Copy the table and fill in the distances. Which part of your skin is the most sensitive?

SENSITIVENESS OF THE SKIN

Part of skin	*Distance between pencil points*
Palm of hand	
Back of hand	
Back of neck	
Cheek	
Forearm	
Fingertip	

Taste

The nerves of the tongue end in small lumps of tissue that are called *taste buds*. These taste buds are sensitive to certain chemicals in food. There are four tastes – *sweet*, *salt*, *sour* and *bitter*. One of the drawings opposite shows the parts of the tongue that give the different sensations of taste.

Looking at a tongue

Get one of your class-mates to put out his tongue. Look at it. Can you see the taste buds?

Smell

The nerve endings in the nose are sensitive to certain gases and vapours. Flavour is often a matter of smell as well as of taste.

Flavour and smell

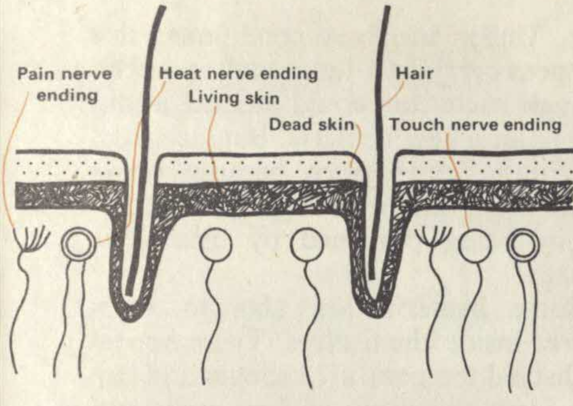
Blindfold a class-mate. Put a piece of raw potato in his mouth. Hold a piece of apple under his nostrils. Change over the potato and the apple several times. Can he tell one from the other? What does this experiment show?

MORE THINGS TO DO

1. Copy the section drawing of the human skin shown opposite.
2. Make a list of the five senses.
3. Write a few sentences about taste and smell.

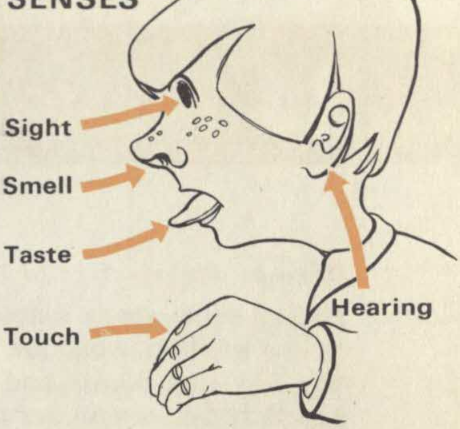
Touch, taste and smell

HUMAN SKIN



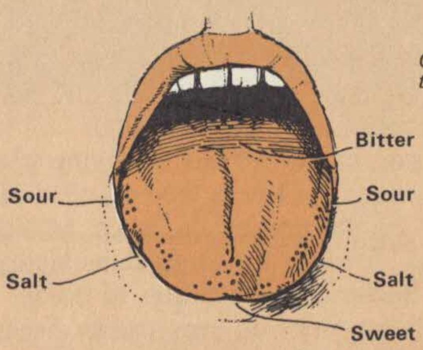
(Section)

THE FIVE SENSES



HOW SENSITIVE IS YOUR SKIN?

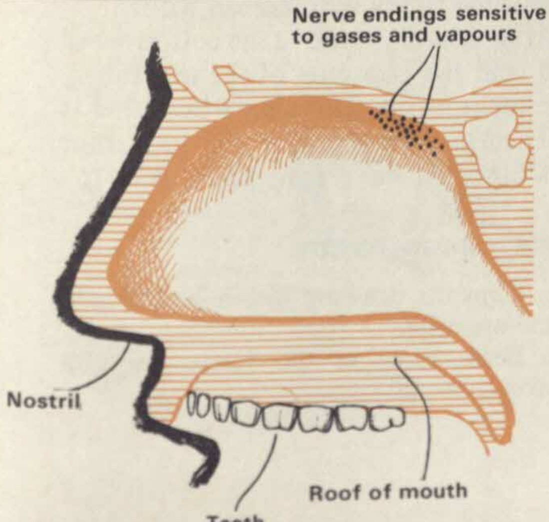
HUMAN TONGUE



Can you see the taste buds?

FLAVOUR AND SMELL

HUMAN NOSE



35 Very tiny plants

Germs

As you know, many illnesses are caused by *germs*. But, what are germs? They are very tiny plants and animals that can only be seen under a microscope. The tiny plants are called *bacteria*.

Bacteria

Bacteria are not green as are most plants. Many are colourless.

Bacteria are to be found almost everywhere – in food, soil, air, water, the mouth and stomach, etc.

Some bacteria feed on living plants and animals. Others feed on dead plant and animal materials, such as fallen leaves, food scraps in dustbins, manure, etc. Bacteria cause things to decay.

All bacteria do not cause diseases. Many are quite harmless and some are helpful to us. Bacteria sour the milk that is used for making cheese.

Disease bacteria

Many diseases of plants and animals are caused by bacteria. Some disease bacteria are shown opposite.

The size of bacteria

Bacteria are so small in size that 5000 of them could be made to cover a full stop. A teaspoonful of soil could contain as many as 600 million bacteria. One of the drawings opposite shows a large *bacterium* compared in size with the head of a pin.

How bacteria multiply

A bacterium multiplies by dividing into two. Under the best conditions, this happens every half-hour, and, in a day, a single bacterium could produce about 280 million new bacteria. But, actually, this does not happen because many bacteria die either through lack of food or by being poisoned by their own waste.

Some bacteria are able to form *spores* inside themselves. These spores withstand temperature changes and can live for many years in dry conditions. When the spores become warm and moist, they grow into new bacteria.

Growing bacteria

Put a piece of moist bread in a saucer.

After a week, look at the bread. There should be some green and white moulds. Also, there will be some orange spots. These are colonies of bacteria. You cannot see each single bacterium. Why? Do you notice a smell?

What has happened? Bacteria from the air have fallen on the bread. They have fed and multiplied. In so doing, they have caused the bread to decay.

Bacteria cause decay

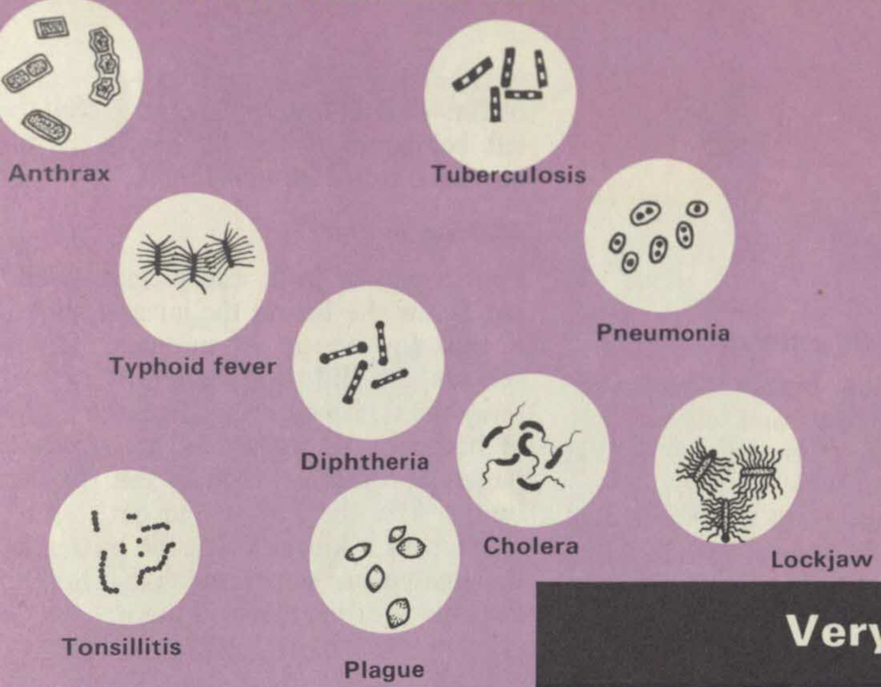
Half fill two test-tubes with water. Put a little minced meat in each tube. Heat the tubes until the water boils. This will kill any bacteria in the tubes. Then, seal one of the tubes with cotton wool.

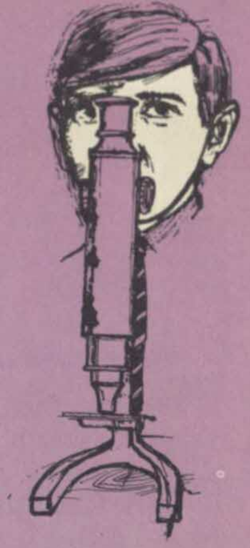
After a week, remove the cotton wool and sniff the contents of the test-tubes. The meat in the tube that was sealed is still fresh. The meat in the tube that was unsealed has "gone bad". Why?

MORE THINGS TO DO

1. Copy the drawing shown in the black frame opposite.
2. Draw some of the disease bacteria shown opposite.

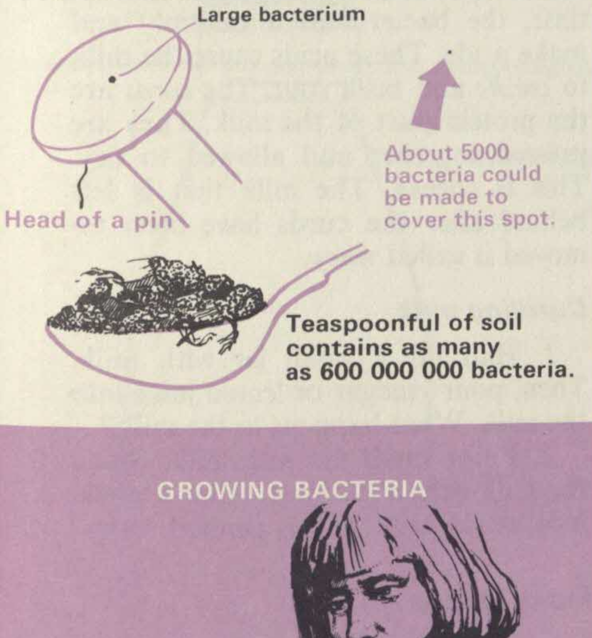
SOME DISEASE BACTERIA





Very tiny plants

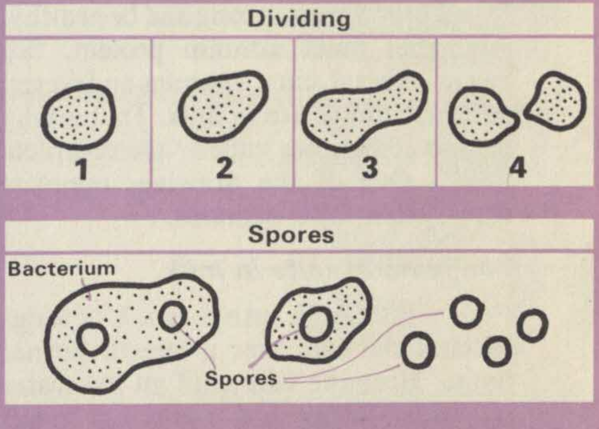
THE SIZE OF BACTERIA



About 5000 bacteria could be made to cover this spot.

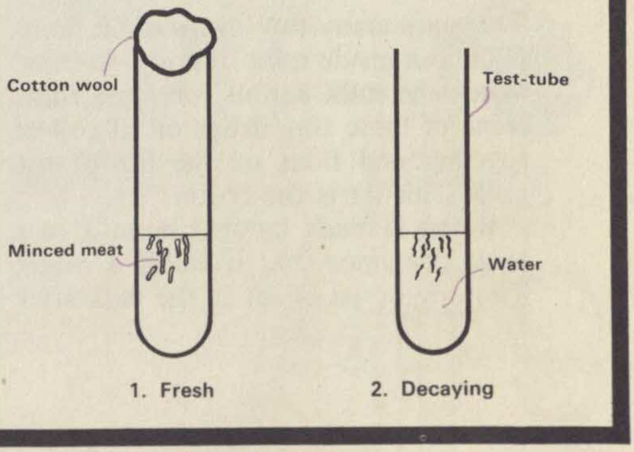
Teaspoonful of soil contains as many as 600 000 000 bacteria.

HOW BACTERIA MULTIPLY



GROWING BACTERIA

BACTERIA CAUSE DECAY



1. Fresh

2. Decaying

36 All from the cow

The cow: a useful animal

Beef, leather, glue, buttons, fertilizers, milk, cream, butter and cheese: all these things come from the cow. It is a very useful animal.

Leather is made from the skin of the cow. Glue and buttons are made from its horns and hoofs. Fertilizers are made from its bones, blood and other waste.

Milk

If you are to grow strong and be healthy, your diet must contain protein, fat, sugar, mineral salts, vitamins and water. All these things are in milk. That is why milk is sometimes called "the complete food". One of the drawings opposite shows what milk contains.

The mineral salts in milk

Pour a little milk into a can. Use tongs to hold the can over a bunsen burner flame. Heat the can until all the water has boiled away and a grey ash is left behind. This grey ash is mineral salts.

Cream and butter

There are many tiny drops of fat floating about inside milk. It is an *emulsion*. When the milk stands for some time, some of these tiny drops of fat collect together and float on the top of the milk. This fat is the cream.

Butter is made by shaking milk in a large container that is called a *churn*. The tiny drops of fat in the milk stick together and so become one large lump of fat. This is butter. The milk that is left behind after the fat has been removed is called *skimmed milk*.

Making butter

Pour a pint of milk into a clean sweet jar. Screw the lid on the jar and shake it well for about 30 minutes. Then, remove the lid and, carefully, pour away the skimmed milk. Drop the lump of butter on to a sheet of greaseproof paper. Sprinkle a pinch of salt on the butter. Mix the butter and pat it into shape with a knife. Wrap the butter in the greaseproof paper and take it home. Perhaps your mother will use it.

Cheese

Cheese is made from sour milk. When milk stands in a warm place for some time, the bacteria in it multiply and make acids. These acids cause the milk to *curdle* and taste sour. The *curds* are the protein part of the milk. They are pressed together and allowed to dry. This is cheese. The milk that is left behind after the curds have been removed is called *whey*.

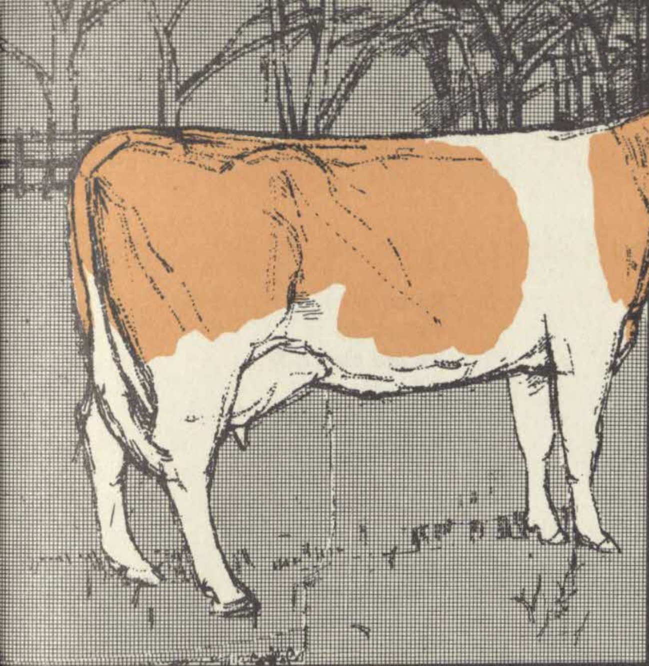
Curdling milk

1. Half fill a small jar with milk. Then, pour vinegar or lemon juice into the milk. What happens to the milk?

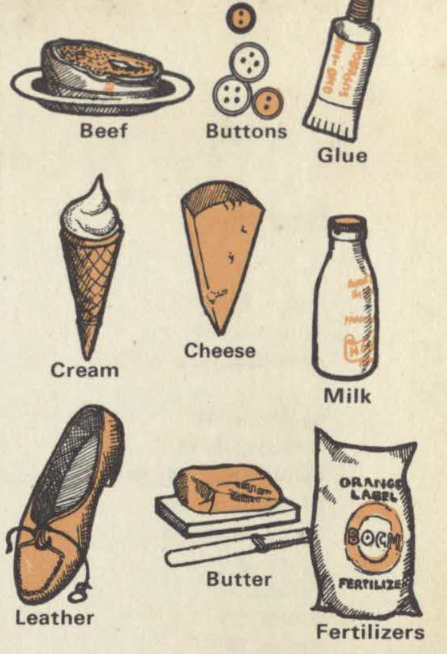
2. Fill a small jar with milk. Stand the milk near a radiator. After a week, look at the milk. It has curdled. Why?

MORE THINGS TO DO

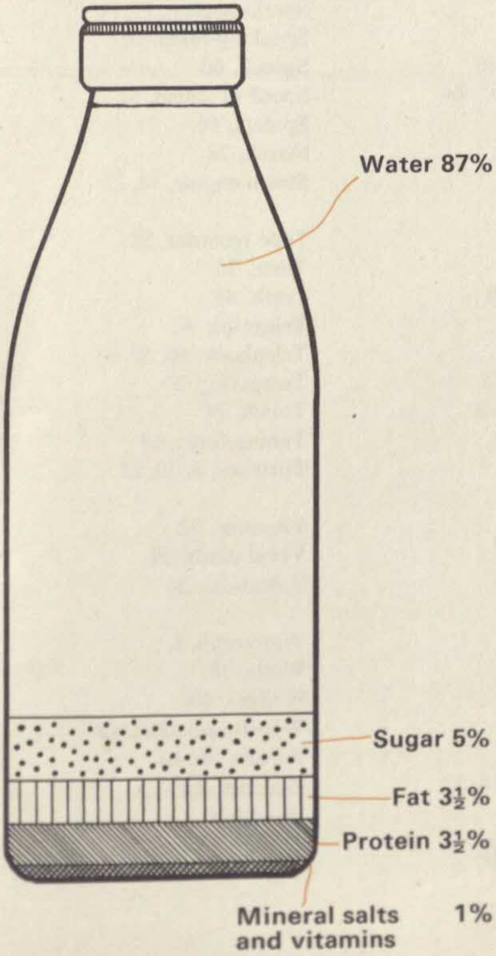
1. Copy the **"What Milk Contains"** drawing shown opposite.
2. Make a list of the things that come from the cow.
3. Write a few sentences about butter and cheese.



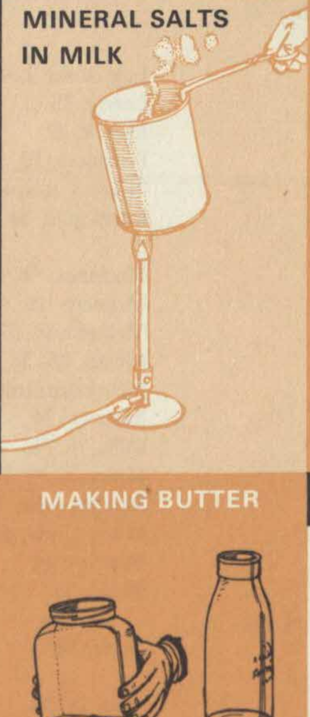
All from the cow

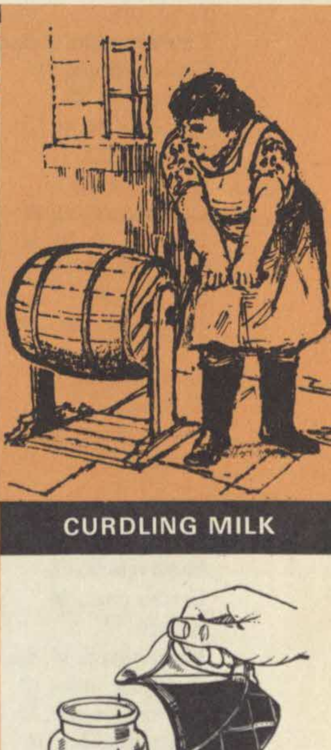


WHAT MILK CONTAINS

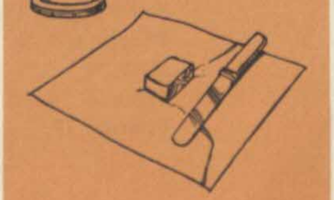


MINERAL SALTS IN MILK

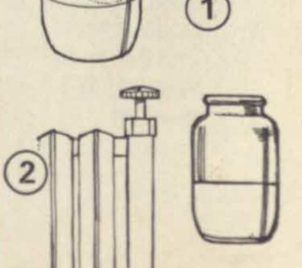




MAKING BUTTER



CURDLING MILK



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